

NASA AUTHORIZATION

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND
SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

SECOND SESSION

ON

NASA AUTHORIZATIONS FOR FISCAL YEAR 1989

MARCH 22, 1988

PART 3

Printed for the use of the
Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

87-269 O

WASHINGTON : 1988

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(III)

NASA AUTHORIZATIONS

TUESDAY, MARCH 22, 1988

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C.

The committee met, pursuant to notice, at 9:40 a.m., in room SR-253, Russell Senate Office Building, Hon. Donald W. Riegle, Jr. [chairman of the subcommittee] presiding.

Staff members assigned to this hearing: Marty Kress; John Graykowski, professional staff members; and Pete Perkins, minority professional staff member.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. The committee will come to order.

Let me welcome our witnesses this morning. I apologize for our late start. Several of us come from different points on the map to be here. Certainly you have, Dr. Fletcher. I was in Michigan. And so, I appreciate the effort by all to be here this morning.

We have had to make one other adjustment in the schedule prior to today because of circumstances. So, it's very important that we have a good sustained hearing today.

I want to say also to you, Mr. Myers, in addition to Dr. Fletcher, that we appreciate your attendance here today.

There are two or three items that I want to stress at the outset before making some summary comments and taking your testimony. The subcommittee is very pleased to be informed that the U.S. and European Space Agency concluded negotiations on a bilateral memorandum of understanding last Thursday night. That clearly is an important forward step for the Space Station program.

Secondly, the subcommittee was pleased to learn yesterday that the administration has agreed to sit down with the Congress to work out the details of the commercially developed space facility proposal. The first meeting is scheduled for this evening, and I'm optimistic that by working together, the executive and legislative branches can agree on a proposal that is in the best interest of the space program and space commercialization.

Finally, the subcommittee was pleased to hear that the House Budget Committee had agreed to a \$10.2 billion funding assumption for NASA in fiscal year 1989. That's a far cry from NASA's budget request of \$11.5 billion, but it is a big step forward for the House Budget Committee and NASA, and the industry should be complimented for their efforts on behalf of the civilian space program. Obviously, that's only the first step, a very long process, nevertheless a positive one.

Now, with respect to our earlier reviews on the effort to complete our rework on the shuttle and get back into safe flight, everything that I see indicates to me that we are making good progress in that area. And clearly, that is the centerpiece of our effort although we have a number of other important things moving forward.

The President this year has requested almost \$11.5 billion for the fiscal year, and that represents an increase of approximately \$2.4 billion from last year. Ordinarily this kind of an increase, fully 24 percent over 1988, would be welcome news. But it is one thing to make the request; it's another thing to find a way to get it funded within the constraints that we see over on the Budget Committee.

This committee is very much committed to making sure that NASA remains strong, that we continue to pursue our major objectives and that we make the strongest case that we can for the budget allocations that we need. It will not be easy to do that given just the tremendous pressure on the budget generally. I thought we did quite well last year in the face of that, and we are faced with the same test in that regard this year.

I would say just one other thing before calling on you, Dr. Fletcher, for your summary remarks, and that is that I think the American people want the civilian space program to move ahead. They are concerned about it as we all have been. And I think they appreciate the tremendous effort that is being made at the top within NASA and by people all through the organization both in the government and in the private sector to get the space program back on track sufficiently.

So, I think the public is counting on us to do the best that we can given all the constraints that we work with. And I think if we put the strongest case on the table for our colleagues in the Budget Committee and in the House and Senate as a whole, I think we will get the resources we need to do the things that we are, I think, wisely advised to do.

So, with that, Dr. Fletcher, we would like to hear from you now.

STATEMENT OF HON. JAMES C. FLETCHER, ADMINISTRATOR, NASA; ACCOMPANIED BY DALE D. MYERS, DEPUTY ADMINISTRATOR; THOMAS CAMPBELL, COMPTROLLER

Dr. FLETCHER. Thank you, Mr. Chairman. I am very pleased again to appear before you as you begin the review of our budget for fiscal year 1989. With me at the table is my Deputy, Dale Myers, and also our Comptroller, Tom Campbell. And also behind me are the various Associate Administrators who will answer details on any questions that you might have.

If you would agree, I would like to highlight the most important parts of my prepared statement and submit the statement for the record.

Senator RIEGLE. Let's do it that way.

Dr. FLETCHER. All right. Perhaps the most important point that I want to emphasize is that this is the crucial year for NASA, a year with opportunities and hazards that will make or break the Nation's civil space program. And I would like to just list three reasons why this is the case.

First, this is the year we will restore the Space Shuttle to safe flight. This is NASA's job. We are working hard on it. Things are going well, and we are determined to succeed. Getting the shuttle flying again is the key to the revival of the space program and to exciting missions of discovery, like the Hubble space telescope and the flights to Venus and Jupiter which will be launched as we are able.

The second point, this is the year that the President has enunciated a national space policy. This policy reaffirms the national goal of U.S. leadership in space. It stresses the key importance of the Space Station for our future in space. It recognizes the emergence of a commercial sector in the space arena and proposes to create opportunities for U.S. commerce in space. And for the first time, it sets the new long-term national goal of extending human exploration and activity beyond earth orbit into the solar system. It thereby opens the door to future missions to the Moon and Mars.

Now, Mr. Chairman, last year you and several members of this committee were encouraging us to set those long-term goals and start on that path. And I can say that the President has signed up to those goals, and we are on track if we can get the budget approved.

The President's policy sets goals and a clear course for the U.S. space program well into the 21st century. I believe it will have strong support in the Congress and the public where there has been strongly articulated concern that our space program has needed a sense of direction pointed at challenging new goals for the future. Support by Congress of the President's policy will make this year a major milestone in the U.S. space program.

The third point, and the most important, this is the year of decision on the NASA budget. This is not an ordinary budget year. It is not an overstatement to say that the entire future of the U.S. civil space program rides at risk in this budget. Let me explain.

The fiscal year 1989 budget we are presenting, which totals \$11.5 billion as you indicated, consists of three main elements. It provides the funds required in fiscal year 1989 to build up the flight rate of the Space Shuttle from one in fiscal year 1988—actually two in this calendar year—to seven in fiscal year 1989, and to 10 in fiscal year 1990. These funds are what it takes to get us back into space and to start flying off the backlog of important national defense, space science, space technology and commercial payloads that have been on hold. Mr. Chairman, that represents the major part of that \$2.5 billion increase over last year.

The second thing it does is provides the necessary buildup of the Space Station funding required in the second year of hardware development. The fiscal year 1989 requirement has been cut back and the schedule revised to reflect the congressional fiscal year 1988 reduction in the first year of funding for Space Station development.

The third thing it does is provides for continuity and advances in space science, aeronautics and space technology; notably, initiation of the advanced x-ray facility satellite for major advances in astrophysics, development of an advanced solid rocket motor to upgrade the shuttle solid rocket boosters, and to open this field for competition, and the new Pathfinder program—Pathfinder is our name of the new technology that goes with the President's national space policy—for developing the advanced technologies that will be required for future decisions to undertake human exploration beyond earth orbit.

The point I want to emphasize is that failure to provide the funds required in fiscal year 1989 for any one of these three main elements of the budget will cut the space program off at the knees and effectively keep the U.S. from achieving leadership in space. If we don't build back the Space Shuttle operations, the backlog of vital defense and science missions will remain on the ground unfulfilled. American astronauts will be denied effective access to space, and our hopes for the restoration of future U.S. leadership will be extinguished.

If we don't move ahead with the Space Station, the teams will be disbanded and the goals of a permanent laboratory in space and a base in space for future exploration will have to be abandoned or deferred indefinitely.

If we can't pursue aggressively science and advanced technologies, we will not have the technical foundation we need for future achievements, and the goal of long-term U.S. leadership in space will become an idle dream.

Also, of course, the country at large will lose the benefits and the economic stimulation here on earth of the advances in technology that we would make from that advanced technology.

This is why I say that both the near and the long-term futures of the United States are at risk in the fiscal year 1989 budget decisions that will be made this year.

Now, I'm well aware, as you are, that the fiscal year 1989 budget that NASA requires and which the President has recommended represents a substantial increase over the total appropriations for fiscal year 1988. The plain fact, however, is that this increase is almost entirely due to built-in increases for building back the shuttle flight rate and for proceeding with the Space Station development on the basis approved by Congress in fiscal year 1988. The other increases are for advanced technology and facility improvements that must be initiated now to assure future U.S. leadership in space and aeronautics.

The President has faced these realities squarely and provided the increases that NASA must have and has done so within the tight overall budget constraints agreed to by Congress and the President last year. The President has provided strong policy leadership and a budget to

back it up. Now it is up to Congress. And I am confident that after your careful reviews, you will recognize the need and provide to NASA the strong bipartisan support in Congress that we have enjoyed in the past.

Before closing, let me remind you that the Space Station is really the key to the future of the U.S. space program both for the full exploitation of space in earth orbit and for human exploration beyond earth orbit. Specifically, the Space Station will provide an in-space laboratory for scientific research and commercial activities, in materials processing, life sciences, earth monitoring, space physics and many other fields. It can also serve as a base for servicing co-orbiting unmanned science and commercial platforms.

The Space Station is also essential for the research and development needed to support future missions of human exploration of the solar system. For example, it is needed to study the effects on humans of prolonged weightlessness. It is needed to develop and test robotic space vehicles and material handling equipment that will operate with artificial intelligence. It is needed to create a reliable space base, self-contained life support system for long space voyages such as a round trip to Mars, which will take two years typically. And it is needed to develop and prove the techniques required to assemble large space structures and future lunar and planetary spaceships.

Later the Space Station will provide the nucleus of the space needed to assemble the spaceships of the future, to provide also orbital service platforms, orbiting fuel depots and things of that sort. These things simply cannot be done effectively unless we have a Space Station as an assembly and a checkout base. Without the Space Station, the U.S. space program will be dead-ended.

While on that subject, I should announce again a new member of our team, Jim Odom, who is coming up from the Marshall Space Flight Center to become the Associate Administrator for the Space Station. And he'll be starting his duties on April 1.

Finally, I would like to point out that the fiscal year 1989 budget will directly support a key element of the President's national space policy, the expansion of the private sector role in space. NASA will continue to implement the mixed fleet of expendable launch vehicles begun in fiscal year 1988 and will procure the needed expendable launch vehicles, or ELV, services commercially from the private sector whenever possible. We will continue our programs to encourage and work cooperatively with private business concerns wishing to undertake enterprises in space.

As a specific undertaking, NASA is offering on a competitive basis to lease a major portion of a commercially developed and financed space facility to be built by a private company for microgravity research and manufacturing. We call this the CDSF. In addition, NASA will expand the opportunities available to the commercial sector to participate and effectively become partners in the Space Station program.

In summary, Mr. Chairman, I believe the President's fiscal year 1989 budget for NASA provides the necessary funding for the right program at the right time. The budget supports what is called for this year, increasing flight rates for the shuttle and expendable launch vehicles to meet the mission requirements, moving ahead with Space Station development, and investing in science and technology in support of the near and the long-term goals of our national space policy. I urge the Congress to join the President as they have done in the past in a national determination to remain foremost among space-faring nations.

Mr. Chairman, this concludes my oral statement, and I would be pleased to answer any questions.

[The statement follows:]

STATEMENT OF HON. JAMES C. FLETCHER, ADMINISTRATOR, NASA

Mr. Chairman and Distinguished Members of the Subcommittee: I am particularly pleased to present to you the President's proposed budget for NASA for fiscal year 1989. We are in a crucial year for NASA and the Nation's civil space program. This is the year in which we will restore the Space Shuttle to safe flight. This is the year in which we must reinvigorate United States' leadership in space. And this is the year in which we must make fundamental technology investments in the Nation's future in space.

The fiscal year 1989 budget reflects the strong priority the President places upon the Nation's civil space program. Much has recently been accomplished to lay a solid base for our fiscal year 1989 budget. We are completing a measured reexamination and restoration of the total Space Transportation System, to the point that we are confident that we will resume safe flight in August, and build up to a total of seven flights next year, with ten flights the following year. Full-scale development of the permanently manned Space Station is beginning, pointed to operational capabilities in the mid-1990s. Key space science missions are in development to take full advantage of launch opportunities on Shuttle and expendable vehicles. Bold steps have been initiated to restore the Nation's civil research and technology base. And the President has issued a comprehensive new National Space Policy, designed to guide United States' activities in space well into the future.

The President's new space policy reaffirms United States space leadership as a fundamental national objective. It reaffirms the Nation's commitment to a permanently manned Space Station as a key to that leadership. The policy adopts as a long-range goal of the United States the expansion of human presence and activity beyond Earth orbit into the solar system, and endorses the initiation of a focused advanced technology program to lay the foundation for later decisions on specific paths our future space exploration will follow. It recognizes the emergence and the importance of a commercial sector in the space arena, and proposes to create new opportunities for U.S. commerce in space.

Mr. Chairman, the President's fiscal year 1989 budget for NASA is designed to support and implement the responsibilities and objectives outlined for NASA in this comprehensive National Space Policy. This budget provides NASA with the resources required to carry forward our ongoing programs and to take the essential next steps to set the foundation for continuing the United States' leadership in space into the future. Now we need your support and the full support of the Congress for this cornerstone budget.

The President's budget calls for a total of \$11.5 billion in new budget authority: Research and Development, \$4.4 billion; Space Flight, Control and Data Communications, \$4.8 billion; Construction of Facilities, \$285 million; and Research and Program Management, \$1.9 billion. While this total budget request represents a substantial increase over the amount appropriated for NASA in fiscal year 1988, most of the increase is required to carry forward the ongoing program approved by the Congress in fiscal year 1988, particularly in the Space Transportation and Space Station programs. The fiscal year 1989 budget recognizes that these planned increases are essen-

tial to carry out our national commitment to return the Space Shuttle to flight, and to proceed with the development of a permanently manned Space Station.

The fiscal year 1989 budget for the Space Transportation System has been formulated to ensure a confident return-to-flight. Fiscal year 1989 funds will support the safe return to Space Shuttle flight operations at a sustained rate in order to restore our Nation's access to space. The effort to redesign the Solid Rocket Motor (SRM) has been, and remains, the driver behind the return-to-flight schedule. Three full-scale firings have been conducted during the past year and three more are scheduled between now and mid-July. Performance of both the redesigned field joint and the case-to-nozzle joint have been superb. Following the Development Motor-9 firing of the SRM, NASA made a determination to employ an earlier successfully tested outer boot ring design for the SRM nozzle assembly. This resulted in a delay in delivery of the flight aft SRM segments to the Kennedy Space Center; however, all of the segments are now at Kennedy and stacking is due to start in early April. All three Space Shuttle Main Engines (SSME) have completed acceptance testing, been delivered to KSC, and are installed in Discovery. Excellent progress is being made on our Failure Mode Effects Analysis, Critical Items List, Hazard Analysis, and Design Certification Reviews. Although considerable work remains to be done, we are confident of completion without impact to launch schedule plans. Movement of Discovery from the Orbiter Processing Facility to the Modification and Refurbishment Facility is scheduled for April. In May, Discovery will move to the Vehicle Assembly Building for mating with the external tank and SRMs. Rollout to the launch pad and the flight readiness firing is scheduled for June, and launch of the STS-26 is planned for August. As the Space Shuttle goes back into operation, we will begin flying off the backlog of defense and space science missions that have been on hold during the shuttle recovery period. The first flight will include replacement of the Tracking and Data Relay Satellite lost on Challenger. Shuttle flight activity in the ensuing months will include three high priority national security missions, another TDRS, retrieval of the Long Duration Exposure Facility (LDEF), and three major space science missions: the Magellan mission to map the planet Venus, the Hubble Space Telescope, and the Galileo mission to Jupiter.

Fiscal year 1989 funding will also provide for launch of selected Science and Applications missions using expendable launch vehicles consistent with implementation of a mixed fleet approach to meeting the Nation's space transportation needs; completion of the implementation of recommendations of the Presidential Commission on the Space Shuttle Challenger Accident; continued construction of a fourth Space Shuttle orbiter; and enhanced capital investment in space transportation systems. These investments include initiation of improvements in Space Shuttle performance, notably programs for an Advanced Solid Rocket Motor (ASRM), and for extending the orbital staytime of the Shuttle. We also will continue to study aggressive advancements in space transportation as full participants in the Advanced Launch System (ALS) program. We expect to complete our studies of the Shuttle C (Cargo) concept in 1988 which will be evaluated as part of the Joint NASA/DOD ALS Program.

The Space Station program remains a top priority of NASA, reflecting the Administration's steadfast commitment to the development of a permanently manned complex in space. The Space Station will provide opportunities for invaluable contributions to materials processing research and life science, as well as expanded opportunities to observe the Earth, the solar system and the universe. It will provide definitive information concerning long-term human endurance in the zero-gravity environment of space. As our national needs evolve, the Space Station could also be an indispensable base for servicing coorbiting observatories and for potential future manned missions. Only with such a permanently manned orbital base can the Nation develop the technology and systems needed to support future decisions on the long-range goals of expanding human presence and activity in space.

During the last year, the Space Station program has made significant progress. We have selected the principal hardware contractors for Space Station development, after an extensive and thorough competitive procurement, as well as several key program integration and support contractors. The National Research Council (NRC) reviewed the program and examined projected costs, transportation issues, and configuration. In parallel with the NRC review, NASA reexamined transportation requirements and furnished a report to the Congress as requested. We are nearing completion of an analysis which

will rephase the schedule for Station deployment in light of the fiscal year 1988 budget reduction and the requested fiscal year 1989 budget. That analysis will also examine options for an early man-tended capability. We have initiated a preliminary design and definition effort for the Station's Flight Telerobotic Servicer. We have developed management concepts for Station science activities and Station operations. We are near agreement with the European Space Agency, Japan and Canada on cooperation in Station development and operations.

In fiscal year 1989, the Space Station will move into full-scale development and construction of key Space Station facilities. Detailed technical design of Space Station systems and elements will be accomplished, aiming toward a Preliminary Design Review in late 1989. This will provide a final set of Space Station technical specifications which fulfills performance requirements within the agreed upon cost envelope.

The President's budget requests \$967.4 million to continue development of the Space Station. Consistent with the recommendations of the National Research Council and the Congress to provide a stable funding environment, the President has also requested a three-year advance appropriations commitment totalling \$6 billion through fiscal year 1991. Later this year, the President will request a total program cost ceiling. The fiscal year 1989 Space Station is critical: failure to provide the full budget request could be a severe setback to the Nation's commitment to U.S. leadership in space.

The fiscal year 1989 budget also underlines the high priority accorded by the President to science and technology generally. This reflects a recognition of the crucial roles of science and technology in the Nation's future. Because investments in fiscal year 1989 will determine the character of the Nation's scientific and technological leadership posture in the decade of the 1990's and beyond, now is clearly the time to emphasize our efforts in these areas. The budget provides for accomplishment of ongoing science programs in a timely manner, provides new flight opportunities in the near term, and moves deliberately toward development of science for the Space Station and its platforms.

In particular, we are moving forward in astrophysics to extend our world leadership in the exploration of space with the initiation of a major new "Great Observatory" project, the Advanced X-Ray Astrophysics Facility (AXAF). AXAF will provide the capability to observe x-ray sources in the universe with unprecedented completeness and resolution. AXAF, together with the Hubble Space Telescope and the Gamma Ray Observatory, will provide a comprehensive physical picture of the universe, supplying a scientific resource more powerful than the sum of the capabilities of these three observatories considered separately.

The budget also underscores the President's newly articulated long-range goal of expanding human presence and activities beyond Earth orbit into the solar system. NASA proposes to initiate, with \$100 million in fiscal year 1989, a "Pathfinder" program of detailed studies and systematic development of technologies necessary to enable and support a range of future manned and unmanned missions, oriented toward a future Presidential decision on a specific focused exploration program. Pathfinder will extend the critical rebuilding of NASA's technology base which was initiated last year with the Civil Space Technology Initiative (CSTI). While CSTI is developing technology to enhance access to Earth orbit and support effective operations and science missions in Earth orbit, Pathfinder will support a wide range of possible future space missions beyond Earth orbit. Mission studies in NASA's newly established Office of Exploration have served to identify a set of technology prerequisites, common to a variety of future missions, which the Pathfinder program will help supply. The Office of Exploration is now developing a set of candidate mission scenarios which include a range of science, exploration and technology development objectives to accomplish the goal of expanding human presence and activities into the solar system. This effort will provide detailed options oriented toward a future decision on focused exploration. While focused, the Pathfinder program is also dynamic—with continuing studies that will refine the program to ensure that critical, long-lead technologies are emphasized.

Significantly, the fiscal year 1989 budget will directly support a key element of the President's National Space Policy: the expansion of the private sector role in space. We will continue our programs to encourage and work cooperatively with private business concerns wishing to undertake enterprises in space. Several initiatives are underway to involve the private sector in developing the infrastructure necessary for research and ex-

pand manufacturing in space. NASA will continue to expand the mixed fleet of expendable launch vehicles begun in fiscal year 1988 by procuring additional needed Expendable Launch Vehicle (ELV) services, from the private sector whenever possible. Commercially developed upper stages are also being used where appropriate for planned missions. Commercial microgravity experiments to be conducted as secondary payloads are being manifested aggressively on planned Shuttle missions. As a major specific undertaking, NASA will act on behalf of the Government to offer on a competitive basis to lease a major portion of a commercially-developed and financed space facility to be built by a private company for microgravity research and manufacturing. NASA will also make its best effort to launch the Spacelab in the Shuttle in the early 1990's and to make the expended external tanks available for five years, at no cost, to all feasible U.S. commercial and non-profit endeavors.

For the Space Station, NASA will, in consultation with OMB, revise its guidelines on commercialization, to clarify and strengthen the Federal commitment to private sector investment and involvement. These guidelines, to be published in the Commerce Business Daily early this year, will incorporate a clear statement of policy, criteria for evaluating proposals including the amount of private sector investment and the degree of risk sharing, and procedures for submitting and reviewing these proposals. NASA has previously solicited proposals, as part of the Space Station bidding process, to provide elements of the program on a commercial basis. We will also consider proposals that accelerate private sector investment in development and operation for goods and services not already contracted. We will seek to rely on private sector design, financing, construction and operation of future Space Station requirements, including those under study.

The fiscal year 1989 program will support a variety of other important programs in science, aeronautics, space technology and space operations. Key elements of the fiscal year 1989 science program include Shuttle launches of the Hubble Space Telescope, the Magellan mission to Venus and the Galileo mission to Jupiter, as well as the launch of the Cosmic Background Explorer on a Delta launch vehicle. NASA will continue the development of the Gamma Ray Observatory, the Upper Atmosphere Research Satellite, the Mars Observer, the Ocean Topography Experiment and the Global Geospace Science Mission. Development of relatively low-cost free flying payloads in the Explorer tradition will continue to progress in fiscal year 1989. Development and integration activity will proceed in preparation for planned Spacelab missions and for secondary payloads to conduct microgravity and life sciences research and experimentation. Augmented effort will be directed toward development of a new generation of flight hardware for advanced experiments in life sciences and microgravity materials sciences, initially on Spacelab and the commercially-developed space facility, leading to comprehensive long-term research on the Space Station. Similarly, life sciences experiment hardware will be developed for use on Spacelab, Space Station, and any suitable commercial space facilities that become available.

NASA continues to pursue a comprehensive strategy to strengthen the space research and technology base. In addition to the continuation of the Civil Space Technology Initiative and initiation of Pathfinder technology efforts, NASA will, in fiscal year 1989, expand its University Space Engineering Research Program to help foster creative and innovative concepts for future space systems and expand the Nation's engineering talent base for research and development. NASA's efforts in transatmospheric research and technology are aimed at accelerating the development of critical technologies intended to enable a potential new class of vehicles in the future capable of flight to orbit and/or hypersonic cruise. Work will continue in the development of technology for hypersonic and transatmospheric vehicles in the National Aero-Space Plane (NASP) program with emphasis on lightweight thermal structures and subsonic and supersonic propulsion. Possible opportunities in this regime include vehicles to transport people to orbit, hypersonic transport between points on earth and military applications.

The fiscal year 1989 Aeronautics Research and Technology program is committed to developing the technology basis for improving the Nation's competitiveness and clear-cut product superiority in the international marketplace, enhancing the safety of aviation, and increasing the margin of the country's preeminence in aviation for national security. Technologies are being pursued that offer the potential of a major increase in aircraft capabilities and substantial positive impact on U.S. competitiveness. Research ef-

forts have been expanded in composite materials, advanced propulsion, and aviation safety.

The fiscal year 1989 Space Operations program will continue to provide vital tracking, command, telemetry, communications, data relay, and data processing to support operational requirements for NASA's flight programs. The transition from a ground-based tracking network to a space-based tracking capability for low-Earth orbital missions, which began with the first Tracking and Data Relay Satellite (TDRS-1) in orbit, is continuing. The next TDRS spacecraft is scheduled for launch on STS-26, with the following TDRS currently scheduled for STS-29. The Tracking and Data Relay Satellite System (TDRSS) will be operational when three fully functioning spacecraft have completed their individual and integrated acceptance tests. The present ground tracking network is being retained until the TDRSS deployment is complete. A procurement is underway to replace the TDRS lost in the Challenger accident to ensure continuity of service through the mid-1990's. Major upgrades of the Space Operations network are also underway to meet requirements of the Voyager encounter with Neptune in August 1989, as well as future mission requirements.

In fiscal year 1989, the Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) program will continue to support NASA goals through activities to promote safety and reduce program risk. While a significant portion of the program effort continues to be directed toward safely returning the Shuttle to flight, attention is also devoted to unmanned space flight and the aeronautics program. Funds will support activities to implement the reporting and documentation of significant problems, assess problem resolutions and analyze trends, and to meet other safety systems requirements.

The fiscal year 1989 Construction of Facilities (CofF) request continues to preserve and enhance NASA's facilities so that research, development and testing capabilities and effectiveness can be maintained. The request is substantially larger than previous years, and marks a concerted effort on NASA's part to restore and modernize a number of key facilities. The demands for NASA's unique wind tunnels are growing with research on high-speed vehicles, including the emergence of the NASP program, and development support for a new generation of military aircraft. In order to ensure wind tunnel availability to meet these demands, an Aeronautical Facilities Revitalization Program has been formulated which begins a structured, multi-year effort to restore and modernize NASA's aeronautical research and development facilities for productive use for the next decade and into the 21st century.

The effective conduct of NASA's programs demands a strong technical and management capability within the Agency. In recognition of this need, last year's budget provided for an increase of 625 people. The fiscal year 1989 budget recommends a further increase of 525 people. This increased capability, which will be applied primarily to strengthen the space transportation program including safety and reliability activities, is a key ingredient in moving ahead in space.

Mr. Chairman, spending on NASA space research and technology development benefits the U.S. economy, industry, education, agriculture, and general welfare. Benefits range from the global: communications satellites which have made events immediate, information instant, and education possible almost anywhere; to the national: advanced welding techniques which allow flawless, continuous welds, improving industrial productivity and competitiveness; to the community: lightweight breathing apparatus which have drastically reduced inhalation injuries to firefighters; and to the personal: insulin infusion pumps that provide diabetics with preprogrammed, correct amounts eliminating multiple daily injections. If history repeats itself, every nickel invested in new space ventures will be returned many fold to the economy. Space can do this again, and give America the advantage in such new fields as artificial intelligence, robotics, teleoperation, process automation, hypersonic flight, optical communications and data processing, ultra high strength and high temperature materials and many more. The most significant economic effects of NASA spending are the long-run productivity advances from new technologies and techniques which improve industrial capacity and stimulate development and growth of many new industries.

In summary, Mr. Chairman, I believe the President's fiscal year 1989 budget for NASA provides the necessary funding for the right program at the right time. The budget supports what is called for this year—increasing the flight rate for the Shuttle,

augmented by expendable launch vehicles, moving ahead with Space Station development, and carrying forward our science, technology and aeronautics programs. This budget is needed for United States leadership in space, and is a sound investment in our future use of space. I call upon the Congress to join the President in an affirmation of National determination to remain foremost among spacefaring nations. Mr. Chairman, that concludes my prepared statement. I would be pleased to respond to questions.

Senator RIEGLE. Thank you, Dr. Fletcher.

I am going to take you through a series of questions we have between now and noontime. We have roughly a two hour window here before we have a veto override vote, and then when we go out for that vote, we'll adjourn during the lunch period and then come back in at about 1:30. And we may adjust that time a little later, but during the morning period, I want to go through a series of discussions in terms of segments of the space program. And I would like to begin with the budget overview.

First of all, let me say I appreciate that fine statement that you have just made, and I think it lays out clearly where we are and the main priorities as you see them within NASA at this point. In terms of the sequence of the questions that I want to put before you this morning, we will go back over some of that material.

And let me just ask you at the outset, as you sort of step back and look at this budget in the overall, is this a recovery budget or is this a real leadership budget. What do we have here in the overall in your view?

Dr. FLETCHER. Well, the budget is a very necessary follow-on to last year's budget. Most of the budget really is not new programs but a follow-on to last year's program. It involves the reinvigoration of the program that we had in mind last year, for example, the Space Shuttle, the increases needed to provide the flight rate and fly off that huge backlog of missions along with the ELVs.

It also involves a follow-on to last year's Space Station commitment. About \$1 billion of the total is for a space station, about a \$600 million increase. And so, it is again a continuation of last year.

It also is an investment in technology, particularly in the continuation of last year's CSTI, civil space technology initiative, but also the Space Station technology.

The main new thrust in terms of dollars is the implementation of the President's national space policy, and that is included primarily in the Pathfinder program. Pathfinder is the beginning of a leadership program. You can't really say that it is a leadership program, but it is the first step and a necessary step. So, in that sense it is a response to your questions last year. But we've got a long way to go in that leadership initiative.

So, basically it is to recover and reinvigorate the space program, and secondary, to start on that leadership initiative.

Senator RIEGLE. And to do this, of course, with that as the general strategy or the assessment of what we're trying to accomplish here, we are being asked for a 24 percent budget increase. Am I right in that?

Dr. FLETCHER. That is correct, Mr. Chairman.

Senator RIEGLE. And so, what you are suggesting to me is I think that we say to our colleagues in the Senate that we are recovering and we are laying out a strategy for the future that has several parts to it. There is not much in here that is new initiative. We have done an analysis that indicates—in this circular graph, the white area, which constitutes 77 percent of the total of the budget request if it were adopted in full, is all for ongoing programs. The area that is marked here, 23 percent if we got the full budget request, are for these augmentations to these initial efforts or movements in some new directions.

So, it seems to me that we are having to say to our colleagues that the overwhelming part of our budget this year is to handle and assimilate ongoing activities, repairs—as you say, the big backlog of activity coming up the line here with respect to shuttle flights—and that that is where we are at this point. And until we do all this, something more ambitious is probably beyond our financial reach. Is that also the case?

Dr. FLETCHER. That's a pretty good description, Mr. Chairman. I think we have set our sights on the long-range goal, and we have got some technology money to back that up. And then we also, as you know, have set up an office of exploration in headquarters that will be designing the various possible initiatives, among them returning to the Moon as a permanent base and also going on for a human trip to Mars sometime in the next century. But basically it is as you say it is, a reinforcement of the NASA program in light of the recovery from the Challenger accident.

I must add to what you say. It surely is a large increase, especially in times of fiscal restraint, but without this increase or the substantial part of it, NASA will be in serious trouble. We really could face a situation, if there was a major cut in that budget, which would be comparable to the Challenger disaster itself.

Senator RIEGLE. As we have analyzed this in terms of the budget request, if we were to take out the space program completely, if we were to take out all new starts in fiscal year 1989, the numbers indicate to us that NASA would still require a 10 to 15 percent budget increase just to hold the 1988 programs harmless.

Dr. FLETCHER. That's pretty close to accurate. I haven't checked the numbers. But I would say that's pretty close to accurate, Mr. Chairman.

Senator RIEGLE. I know you want this request and you are making a strong case for it, and we're going to do what we can to try to meet that request.

If we were to try to say, however, what is the absolute rock bottom minimum that we need to prevent what you have described as something the equivalent of another accident to the program in terms of a major setback? What are we talking about in that area? Is there an absolute rock bottom minimum that we have got to have without serious harm being done?

Dr. FLETCHER. Well, Mr. Chairman, the Space Station will survive no matter what cuts are made. But I think unless we get full funding for the shuttle that we have asked for and a continuation of the buildup of

the shuttle flights to fly off the backlog, at least that amount of money. I think we will set the program back quite a large number of years because we really have to begin the Space Station over again. We can't keep the contractors going on the amount that we had for last year, for example. That was enough to keep them going last year, but not this year. And I think we'd have to really begin again with the next administration on the Space Station, plus we would have lost our initiative in moving out toward the Moon and Mars. So, I would say the rock bottom minimum is pretty close to what we're asking for.

Senator RIEGLE. What date do you have in your own mind right now if we can get the funding that we are seeking here for a Space Station that we would actually have an operating space station?

Dr. FLETCHER. Well, we're still in the process of making those analyses, and I think we owe the Congress a proper response the first week or two in April. But it looks pretty definite that it would be about a one year slip because of last year's cut. And so that would mean we would start the first element launch in early 1995 instead of 1994. And I guess that 1997 or 1998, in there somewhere, would be the permanent manned capability. But those dates are still being worked, Mr. Chairman.

Senator RIEGLE. I must just say I'm for the Space Station, and I think it is a step that we need to take. And I think it offers a number of important benefits to the country. And one of those is the international consortium aspect of it. But I must say that the notion that we are looking at a 10 year time period here before we are really up there with a space station—and I mean an operational space station. And, of course, we have slippage all the way along the line. And so, one can assume that probably, the timetable lengthens. It won't shorten unless there were an all-out national commitment to shorten it.

I must say the idea that, while we should do it and we want to do it, and we're going to do it, the fact that it is going to take us a decade to do it from where we are today hurts our case. I think it makes it difficult for the Congress under the kinds of budget pressures that we have today to be able to make that kind of a case and commitment compelling enough so that people feel like that should be given the same weight, say as an increased funding for fighting drug traffic or AIDS research or education or a host of other competing areas that are all seeking additional funding.

But I guess we come back around and we say to ourselves if we're going to do it right, we're going to do the Space Station the way we envisioned doing it. It's basically a 10-year haul. I mean, isn't that essentially the hard fact of it?

Dr. FLETCHER. Mr. Chairman, it is a 10-year haul from the time that it started to the time it first—you see, it started in the State of the Union message in 1984 or it could be a 10-year haul from now until the Space Station is completed and operating with permanent manned capability.

It is a long haul, but part of that is due to the various problems we had last year. I had hoped honestly to finish the Space Station in a much earlier time, but because of the increase in the cost or perceived increase in the cost of the Space Station, and because of last year's devastating cut in the Congress, it has pushed the Space Station out. That is why I say this year is crucial, and we have got to step up to it and go. Otherwise, we might just as well forget it and start over again at some later date.

Senator RIEGLE. Well, the budget runs that we have indicate that we have fallen short of our funding targets, and so that has had the effect of stretching the schedule.

My concern is I think in order to infuse this with enough meaning and to fire the imagination of people in the Congress and across the country to cause them to want to make kinds of serious long-term money commitments that are required, it just gets harder to do the longer that timetable appears to be. And I'm just thinking out loud here with you because I want to try to think through whether there is any way that somehow we could shorten that time frame.

I know that is a hard thing to think about, but it seems to me that with the Russians up there today, as they are, with a functioning station—they have been up there now for a long time—and if our best effort, if we were to really pour on the effort at this point, we are talking about being fully operational 10 years from now. Despite the fact that that makes very sound sense from an engineering and planning point of view, I'm not sure it has the right ring or the right sense of importance and meaning to the people who are going to have to pay these bills.

Dr. FLETCHER. Well, I think I agree with what you say, Mr. Chairman. I should add, though, that even if we get the full funding this year—and by the way, it is down. The run-out from last year was \$1.8 billion, and we felt that we couldn't increase that rapidly. So, the amount is \$1 billion for fiscal year 1989. If we get that amount, then the first element launch will be in fiscal year 1995, and we will be doing useful things in fiscal year 1995, which is only six years from now or five years from the fiscal year 1989. In late 1994 or early 1995, we will be doing microgravity research on the Space Station. So, it's not the 10 year program, it's more like a five year program before it is doing useful things.

That doesn't mean to say that we don't have to have the full funding this year. We do have to because if we don't, you are quite right. It is being stretched out too long, and we might as well forget about it.

Senator RIEGLE. When you talked with the President—and I assume you had the opportunity to talk with him directly about this—do you get the sense that he feels strongly enough about the Space Station that he is really going to put his muscle behind it?

Dr. FLETCHER. I believe that is the case, Mr. Chairman. The President has signed up to help sell this program this year. And if he gets beyond his current crisis, I think he will do so.

Senator RIEGLE. He's a great salesman. If you can get him talking about this, that would help.

In terms of OMB, I take it that you submitted a larger request to them and it was shaved down. Is that right?

Dr. FLETCHER. Yes, indeed. We accepted the shaved-down budget because of the budget summit agreement last year. We just didn't see how we could get through anything higher than the 24 percent that you mentioned.

Senator RIEGLE. But on the Space Station, how big was the cut from OMB? What did you want?

Dr. FLETCHER. We had asked for \$1.8 billion, and we were cut back to \$1 billion. And \$1.8 billion was last year's run-out. But we were also cut back in a number of other areas which are important things to do, some of them science areas, the Shuttle C was cut back, and quite a few other things.

Senator RIEGLE. Did you request a three year appropriation for Space Station, or was that an OMB initiative?

Dr. FLETCHER. Well, that was done in discussions. It was first raised by the Congress, actually, last year in some of the discussions that we had. The Congress, we in NASA and the White House all feel that we need more stable funding for something like the Space Station. As you point out, that is a long haul from the start to finish. And we need some sort of stability in funding.

So, during the discussions with the OMB, we came up with this idea of a three year appropriation. And we had to develop different techniques for doing that. And I believe the way it is recommended is that we appropriate for each of the three years, fiscal year 1989, fiscal year 1990 and fiscal year 1991, a total of \$6.1 billion, but appropriated by year.

Senator RIEGLE. I understand that on the 12th of December you issued a stop hiring order for the Space Station program support contract; and that you have also implemented a hiring freeze because of the reductions in the 1988 budget; and, if my information is right, that there is no request included in the fiscal year 1989 bill for Space Station civil service personnel. And I'm wondering if that is right. Does NASA really have the ability to manage and implement the Space Station program?

Dr. FLETCHER. Mr. Chairman, let me review the bidding on that one. We had a freeze, to be sure, last year because of the action taken by the Congress at the end of the last session. We had a total of a \$100 million cut in our R&PM budget which supports the civil service personnel. And therefore, in order to meet that cut, we had no choice but to put a freeze on because in the process of putting together that omnibus bill last year, no transfer authority was allowed. We couldn't transfer to another fund, which we often do from, say, R&D into R&PM. And for that reason, we had to either furlough a lot of people—that is, just not pay them as much—or freeze. And we thought the least harmful would be to freeze.

We are hopeful that very soon in fiscal year 1988 we will come forward with a supplement which will give us that transfer authority, not with more money because that's not allowed under the summit agreement, but allowing us to transfer a small amount, something like \$40 million into the R&PM budget, in which case we will then be able to proceed with the replacement of the people who are now leaving.

In fiscal year 1989 it is quite different. In fiscal year 1989, we asked for a major increase. I think it was 2,250 people. And it was cut back to 525 which did not include the necessary personnel for a space station.

We were given to understand, though, in the process of doing that because of all of the motion in the Space Station caused by last year's budget cut, we were to come back in the spring and discuss the needed personnel for the Space Station. But they weren't going to commit for the increase in the Space Station personnel until we were on solid footing on the Space Station itself. And so, the total approved would be something on the order of half of the 2,250 that we asked for if the second increment is approved, but we are in some difficulty on Space Station personnel right now. Yes.

Senator RIEGLE. Am I correct in understanding that there is a request for about 500 people that is under review at OMB now?

Dr. FLETCHER. That's the extra 500 people that I have referred to. That is going to be reviewed this spring after we get a little better idea where we are on the Space Station program as a result of last year's cut.

Senator RIEGLE. Let me ask you this. What is the meaning of the phrase—and let me quote as follows. "Later this year the administration plans to request legislation to establish a total program cost ceiling." This is with respect to Space Station. What can you tell me about the meaning of that?

Dr. FLETCHER. Yes. There has been, you might say, a credibility gap on the part of some in the Congress and some in OMB on the total cost of the Space Station. And we said let's put that credibility gap to bed. We are ready to sign up for a fixed price, so to speak, for the development of a space station. And so, OMB said fine, if we get the three year funding from Congress—that's the \$6.1 billion that I referred to—let's put a ceiling on the overall so that if Congress signs up to the out-year funding, we will meet that funding target. And we will have that figure ready for you in the spring.

Senator RIEGLE. Let me just ask you one other thing at this point, and in a moment I'll turn to Senator Bentsen.

As I understand it, as we look forward here, if you take the items that you are requesting and you work them out over the next two or three years just in terms of the planned growth of those activities and the required support for those activities, that that would show us by fiscal year 1992 an annual budget in the range of about \$14.8 billion. Is that about right?

Dr. FLETCHER. Mr. Chairman, that is about right if you take inflation into account. Everything depends on—

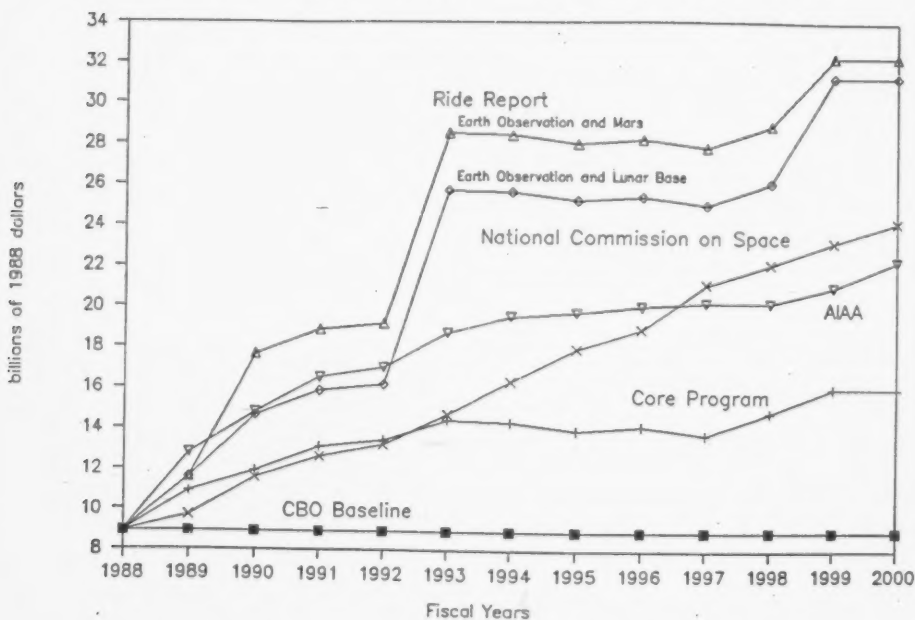
Senator RIEGLE. It would be nice if we could stop inflation.

Dr. FLETCHER. Well, we always have to take 5 percent inflation into account in our out-year funding. In constant dollars, it is something closer to \$13 billion which I think is the amount of money required to run the space program. And we will be up to that well before the 1992 period. It will be approximately a level budget out in those out-years.

Senator RIEGLE. We have prepared a chart here. And I don't have enough copies to send around. But I just want to make a reference to it. I'm going to insert it in the record.

[The chart follows:]

NASA BUDGET OPTIONS 1988 THROUGH 2000



Senator RIEGLE. We have tried to lay out over the 10 years, or 12 years actually, through the end of this century, some cost lines that would express what is required to meet certain goals that have been recommended by various bodies that have looked at space policy.

For example, if you take the Ride Report and you cost out what it would take to implement those recommendations—that's the cost line at the top—and it would show us spending at an annual rate out in the year 2000, about \$32 billion. This is quite substantial and obviously would be a very ambitious program. If we are going to do those things, they are not cheap.

If you come down a notch to what we have listed as an earth observation and lunar base centered strategy, that is also quite expensive, less so than the full scope of the Ride Report.

Then if you take the National Commission on Space, that falls in at a rather high level.

And then as we come on down, and we finally get to the core program, which is essentially what we are talking about here today, that still shows upward growth. We get up into the range, quite early in the next decade, of \$14 billion a year. But that, of course, is quite substantially below these more ambitious goals that cost us a great deal more if we want to go that way.

But even then if we take the core program, we are still talking about something in the range of \$14 billion to \$15 billion in fiscal year 1992. And I take it that you agree that those are the kinds of numbers we are looking at. And that is just to sort of stay on the current track.

Dr. FLETCHER. Mr. Chairman, I certainly agree with your estimates of the core program. It is a bit premature to guess at the cost of the National Commission on Space requirements and the Sally Ride report requirements. That really depends on the technology that is performed between now and then.

But certainly the core program is going to run on the order of \$14 billion. That is what it takes to run NASA. We have been underfunded all these years, and that is why we never quite get off the ground on some of the things that you have been asking us to do.

Senator RIEGLE. And I think it's important to say that. We don't want anybody to be fooled about what it takes to do the job, and we are not going to get anything that we are not prepared to invest to get. If we want to set important and dramatic goals that are difficult and complex and require the best technology that we can put together, we have to be prepared to pay for it. It is just about that simple, isn't it?

Dr. FLETCHER. Yes, Mr. Chairman, I agree, and it seems like a large amount of money, and it is a large amount of money.

But just let me remind the audience anyway—I don't have to remind you—that the space program is mighty important to this Nation. It provides the technology required to do a lot of other things throughout the economy. It returns to the economy, as we have said many times before, \$5 for every \$1 invested. It provides an inspiration for the young people we are trying to educate nowadays. We are losing people in science and mathematics at the elementary and secondary schools. It provides that. And when you add all that up, and even at the \$14 billion level, it is less than 1 percent of the total Federal budget. So, it is a small price to pay for a reasonably vigorous space program.

Senator RIEGLE. Senator Bentsen, let me ask you if you have any opening comment you would like to make or questions you would like to ask.

Senator BENTSEN. I do have some questions. Thank you very much, Mr. Chairman.

Dr. Fletcher, I'm delighted to see you. And I, of course, enthusiastically support what the President has asked for with his 24 percent increase in the budget for space technology and science. But it is going to be a tough one to attain. And in trying to establish the priorities, we have got a selling job, to do particularly those of us on this committee, in convincing our colleague that this amount of the budget should be expended for this purpose. One of the things that I am interested in

seeing and I welcome is the administration's eagerness to develop the commercial part of space.

But I am concerned about some of the reports of disagreement over the proper roles of NASA and the space entrepreneurs. It seems to me space ought to be big enough for both of them, and there is no question that the technological breakthroughs—the big ones—are made by NASA and they are made by the government. They're the only ones that really have the resources to go that far.

On the other side of it, you look at the private entrepreneur and he is looking for an evolution. He is trying to find ways to put ideas into products that can be transferred to the benefit of the people and be commercialized.

I am concerned, though, again about some of the controversy I hear developing in that regard. And I would like to have your comments on it.

Dr. FLETCHER. Well, I think part of the controversy is much ado about nothing because we completely agree with the statement that you just made that the private sector is a major player in space and should be. We at NASA have always encouraged the private sector participation beginning back in 1962 when we launched the first communications satellite. I believe it was Telstar, and then we followed that by another one, Sycom, and now we have a thriving communications satellite industry.

If you look at the future, it is very clear—and it has been to all of us for some time—that the materials processing, the development of new pharmaceutical products, biological materials, all of these things, can be developed in space at zero gravity. And we are trying to encourage the commercial sector being involved and have done so.

But, of course, with the accident, there has been a hiatus and now we are trying to catch up again with those folks as we have in the science program. And we find we don't have enough flights. We don't have enough space and so forth prior to the arrival of the Space Station. And so, we have been looking at various ways to augment the commercial access to space in these important areas.

And the only controversy that I know of which is greatly exaggerated was how we would encourage one particular facility, which we now call the commercially developed space facility, how that would get off the ground with partial support. And I think we have a way figured out. And I'm going to ask Mr. Myers to give the latest on that because he has been working this problem very hard.

We do have agreement that it should be commercially competitive and not a sole source because it looks as though we're going to have to put somewhere between \$400 million and \$700 million into it. That's a lot of money to support a commercial enterprise. And we think that if we sign up for a portion of the use of that facility, we will get our money's worth.

But we have to be careful that we don't freeze out the commercial users as well. And so, very shortly, in the next week or two, we plan to have an RFP which does just that, but maybe Mr. Myers could comment.

Senator BENTSEN. That is encouraging to hear, Dr. Fletcher, because I do think you have to have a shared approach on this for the commercialization and a cooperative agreement between government and the private sector, and a division of labor that takes advantage of the particular talents of each. But I would like to hear from Mr. Myers.

Mr. MYERS. Senator, we are in the process of developing a request for a proposal based on NASA being the agent for the government in bringing about this commercially developed space facility. It turns out that several areas of the government are interested in microgravity research. And in our view the opportunity was arising where we could have a commercially financed, designed, developed, owned and operated facility that we would be an anchor tenant in—we, the government --perhaps leasing up to 70 percent of the facility, to be able to encourage the industry to see that there really was a firm set of requirements that they could base their business plans on to go to the financial community to get the funding to develop a program of that nature.

The approach we are taking is that we would lease up to 70 percent of the facility for a period of five years starting in the 1992-93 time period. It would mean that there would be no funding required by the government prior to that time. It would mean that it would be financed by the private industry to develop and produce that device. When it is delivered flight-ready to the Cape, we would then start the clock running on a lease arrangement with them starting in 1992 or 1993 and then for a five year period.

We would also arrange that if there were a growth of commercial payloads, the offeror of the CDSF would be able to take over more of that anchor tenancy that we would have so that there would be an opportunity for the growth of the commercial industry across that time period as the commercial industry learns from our experience and others the kind of devices that they want to put into space.

It has turned out that because of the encouragement of the Congress in our areas of microgravity, our funding has increased in that area. And we are doing now some really world-class microgravity experiments in the Spacelab and we will carry some of those in the CDSF as anchor tenants.

We have improved the down payload capability of the shuttle over the last year, and that allows us to carry larger payloads of this nature into space. And we think we have now an opportunity to get a privately invested, privately built facility properly integrated from a safety standpoint by NASA to carry commercial and government payloads in the time period of 1993 and beyond.

Senator BENTSEN. And in the negotiations with the private sector, you feel like you are achieving an accommodation?

Mr. MYERS. We are doing all we can to make it an opportunity that the investment community can meet. What we are doing is—

Senator BENTSEN. Well, you are consulting with them?

Mr. MYERS. Yes. We are consulting with the industry. What we have done is we first sent out what we call a statement of work which would define in broad, general terms the requirements that we would see as

the proper device to give us opportunities for both commerce and government. They have responded to us with their ideas. We have incorporated that in our request for proposal.

We have a request for proposal essentially finished, but we want to review that with Congress. We want to review the basis of that request for proposal with the Congress we release it. We are intending to release it by the end of this month, but we have some time that we can go over what is in it with the staffs and with the Congress before we release it.

But I think we are listening to the industry as to what their needs are in this activity. It is a difficult thing for industry to finance because \$700 million is a major investment for industry. And so, we are doing all we can.

Senator BENTSEN. And it is a relatively high risk situation.

Mr. MYERS. Yes.

Senator BENTSEN. And you are talking about the government money not being available until 1992? Is that what you said?

Mr. MYERS. Yes. The idea is to assure that we will lease the facility starting in 1992 or 1993. We asked for it to be delivered by 1993, but if they can accelerate that time, it would certainly be very welcome.

To do that, of course, we are going to need the support of Congress because I'm sure there are activities that have to occur to assure the industry that we will, in fact, pay out that lease money across the five year period. And we think that there is a need for that kind of support from Congress before we can really get on with the job.

Dr. FLETCHER. Senator Bentsen, could I just add one thing just to make sure? We have to consult with Congress because in order to get these folks started, we have to have some sort of a commitment from Congress as to the funding in the out-years. Otherwise, they're not going to make the investment. And so, that is why it is absolutely necessary that we sit down with your staff and the staffs of other committees and work out a reasonable request for proposal.

Senator BENTSEN. That is a good point.

Dr. Fletcher, on my bill to have a space grant college and fellowship program, you and your staff were most helpful in formulating that and putting that into effect. And I had been concerned wondering about how much was going to be committed to get the program started. And I wrote you asking for those details, and just yesterday I received a reply, I might say to the Chairman and for the record here, saying that you hope to fund the program in fiscal year 1989 with some \$8 million to \$10 million. And I think that is an excellent start.

And you had stated earlier we have to get some more young people into this program and we have to stimulate them. And there is no question but what we had a great interest in the space program, and that brought a lot of young people into that program years ago. But then we have had a bit of a lull in between, and it is important that we get that started up again and we bring in a new wave of bright, well-educated people into the program. And I think this will be of much help. And I am appreciative of the effort that you have done in that regard.

There is one other matter I want to talk to you about for just a moment. We were talking about, having an effort made on an industrial space facility. And there is some concern about that as to what should be done. We had talked previously about urging NASA to give us a report on that in a way that the facility could enhance U.S. space science and Space Station programs.

I understand that report has not been formulated yet, and I would like to have your comments concerning that. I know some people look at it as an alternative to the Space Station. I certainly don't.

Dr. FLETCHER. Senator Bentsen, you are absolutely right. This is certainly not an alternative to Space Station. But it is a way to allow the commercial sector to get involved earlier, and we consider it as an adjunct to the Space Shuttle in addition, for example, to the Spacelab which is already funded, and in addition to the secondary payloads which are mid-deck experiments. We really need more space and more flights with commercial involvement.

The ISF—we keep getting terms mixed at NASA—is the term used by a group in Texas, the Space Industries Partnership, in the days that we first signed up with them to launch it and then be reimbursed for the launch by the commercial sector. It turns out that the commercial sector didn't have the funds because of the accident and so forth. So, we decided we had to go competitive on this because we had, as Mr. Myers said, to be an anchor tenant. And when it went competitive, we then didn't drop the ISF because we are still signed up with that original memorandum of understanding. But we developed a new term which we call the commercially developed space facility and, of course, that's the one that Mr. Myers was describing.

It's a little confusing because we already have an agreement with the SIP to launch them if they could find the customers that they had originally planned.

Senator BENTSEN. So, it has been spread across. It is in a broader context?

Dr. FLETCHER. It is in a broader context and we have signed up for some of the money.

Senator BENTSEN. That helps me better understand it.

Mr. MYERS. You know, I think, Senator, the simple answer to that is that when people came to us with the commercial payloads, fully funded, fully developed programs with commercial payloads, we would take them as a commercial customer and put them on our manifest. When it turned out that the ISF, which was a commercial group, wasn't able to develop the commercial market, and the government stepped in to become an anchor tenant, we felt then using government funds we should have a competition. And so, we are competing the CDSF for a similar capability.

Senator BENTSEN. I'm sure that this has been touched upon, but I would like to hear, Dr. Fletcher, from you when the President seeks his \$967 million for the Space Station, he also wants a three year commitment to a \$6 billion program. You will find Congress very reluctant to give long-term funding for big programs and programs that are some-

what controversial. Perhaps you could outline some of the advantages, some of the savings, that would take place in trying to have a more stabilized program with that kind of a forward commitment, if you would help make the record on that one.

Dr. FLETCHER. Well, Senator Bentsen, I would be glad to address that question.

We really have never asked for a three year funding before to the best of my knowledge at NASA. But it arose from discussions that we had in this committee to a degree and also over in the House as to how we can be a little bit more careful about the up and down funding that we got for other long-range programs, such as the Space Shuttle. That was the thing that concerned us. We really cut corners on the Space Shuttle, and hadn't realized, at least in headquarters, what we were doing to it.

And so, based on that shuttle experience, and based on the experience we had last year in the Congress of a major cut in the Space Station funding, and also discussions that we have had with all of you, it seemed like we had a reasonable chance of getting from the Congress a three year commitment. And if we do that, then we can produce that fixed price cost that I mentioned earlier.

For example, it is quite possible, although we're still not through reviewing it yet, that the cut last year added something like \$700 million to the total cost of the program. Well, we can't keep doing that. And in the process, we don't know what things we cut out that we shouldn't have cut out. However, it is at the beginning of the program, and so probably nothing really bad happened last year except a delay in the funding.

We think if the Congress will sign up for the full \$6.1 billion, not all at once, but in one-year increments, we will have a start to that program which will give it to the country at a price that we have specified and we are pretty sure of the price where we wouldn't sign up to that fixed price contract.

And I think it would make us all feel a little better about the safety of the Space Station.

So, these are some of the arguments behind it, although I realize it is a new first for NASA and is probably a little bit of a shock to the Congress.

Senator BENTSEN. A bit of a shock, but I am sympathetic.

I would like to close. When we were talking about my scholarship bill—and you are going to go for \$8 million to \$10 million. Just tell me the line item I have to protect, Dr. Fletcher.

Dr. FLETCHER. We will do our best.

Senator BENTSEN. Be sure I'm fully advised of it.

Thank you very much, Mr. Chairman.

Senator RIEGLE. Thank you, Senator Bentsen.

Let me just say that your initiative on the space college grant and fellowship program I think has been very important. You really have been the one who has developed that idea and you have pushed it forward, and now we are moving and I think that has been a very significant step forward. And the committee appreciates that.

Senator BENTSEN. That is very generous of you.

Senator RIEGLE. We are going to see great benefits from that I think as time goes on.

Senator BENTSEN. Mr. Chairman, I have another committee I have to attend. If you would forgive me.

Senator RIEGLE. Thank you. Did you need my proxy to take with you, if you're going to Finance?

Senator RIEGLE. Admiral Truly, I thought I saw you. I don't have my glasses on right now. Why don't we have you come on up to the table, and we are going to move now into some questions on Space Flight. And we may have other questions that we will submit for the record with respect to the overall budget issues that we were discussing before.

We are delighted to have you at the table and would like to move through some of these areas.

Admiral TRULY. Thank you, Mr. Chairman.

Senator RIEGLE. Compared to the fiscal year 1988 operating plan, the 1989 budget request for the Office of Space Flight has been increased \$900 million, or approximately 26 percent. We are up from \$3.5 billion to \$4.4 billion.

Now, if any reductions were made to the shuttle production capability development or shuttle operation accounts, would that adversely affect the fiscal year 1989 launch schedule of seven missions?

Admiral TRULY. Mr. Chairman, it would. And the severity of the impact to the manifest and to the launch schedule naturally would be directly related to the cuts, should they come.

Over the past year we in the Office of Space Flight have spent a great deal of time on our total transportation budget which is an underpinning of the capability of this year's total NASA request, but particularly on the shuttle program costs. As we have gone through the recovery period—and incidentally, I might tell you that I think the recovery is going extremely well and we are heading for an August launch.

The management of the program—personally myself and Mr. Autridge, who is not here today—has spent a great deal of time on the subject of cost. It has been scrubbed over and over again. It is required not only to bring us to August and the first flight, which of course are fiscal year 1988 funds, but then to move into a reasonable and safe flight buildup in fiscal year 1989 and the out-years.

And that first year flight contained some of the civil space program's most important satellites and programs. There are two tracking and data relay satellites in that first half dozen flights or so. There are a couple of very important Department of Defense payloads. Magellan is coming up I think on flight 5. Hubble Space Telescope is right around the corner. And as a matter of fact, we have now just last week—we now have six crews that are announced and in training. And I believe the last of those six crews is for flight 6, which is Hubble.

So, we think that the monies that are in the budget are carefully scrubbed and represent what is required to safely bring the shuttle back into business and give it the proper resources, both dollars and people,

to build up the flight rate, but do it in the manner that we are determined to do it in.

Senator RIEGLE. So, I take that to mean then that you are saying that you are down to the rock bottom minimum, and if we're going to hit that seven mission launch schedule in 1989, you have got to have every penny you're asking for?

Admiral TRULY. Yes, sir. I believe that.

I would also say that once we get back to flight, a great portion of the shuttle operation is not—you can't take a lot of that away from the operation just by deleting one flight. Now, obviously, if you delete one flight, you don't have to buy the external tank or the two solid rocket motors, and there are some savings. But underlying the total shuttle program is a capability of people and resources and production and quality insight and so forth. So, it is difficult to find places in the budget that are flight rate-related that give you a whole lot of relief.

Senator RIEGLE. Let me ask you what new initiatives are contained in the Office of Space Flight budget for 1989 and how would you rank those initiatives in order of priority.

Admiral TRULY. The new initiatives are first the advanced solid rocket motor which I rank number 1. We need this motor for two big reasons in the future. One is to make us feel more comfortable with the safety and reliability and maintainability of the solid rocket motor in the future and, secondly, to regain performance for the shuttle system which also turns into money and payback once you have that performance. And I would rank the advanced solid rocket motor number 1.

In our budget request or a portion of the request is for the people in the R&PM budget that are part of the resources, the dollars and people that have to stand beneath the safe shuttle operation.

Also, there is a request for funding for an extended duration orbiter which would extend the duration, for example, of the Space Station missions from about 7 to 9 days out to about 16 days. And in working with our science people, we think that instead of just getting double the science on a flight like that, that you would get close to triple the science. And so, there is a big payback there. But I would rank that lower than the advanced solid rocket motor program.

Dr. FLETCHER. Mr. Chairman, could I just interrupt because when you asked Admiral Truly what his priorities are, he will give you the priorities from his perspective. From a NASA perspective, all of these are high priorities. We need every one of them because some of them affect other parts of NASA. So, I would say the ASRM, the Space Station support, the advanced launch system, and the EDO are all very high priorities for NASA.

Senator RIEGLE. Let me just run down through a quick series of questions on that. Then we have two colleagues that are here that I want to call on very shortly.

With respect to the advanced solid rocket motor, Admiral Truly, based on the studies you've conducted to date, can you tell us what your findings are with regard to the segmented versus the monolithic boosters, the so-called COCOs versus the GOCOs, and candidate sites for this new ASRM facility?

Admiral TRULY. Yes, sir, I'd be pleased to.

First, the first part of your question has to do with the design of the motor itself, and we have had five contractors on contract doing preliminary looks and specifically as to whether we should build a monolithic case—that is, a single pour of solid propellant in a single large case—or whether we should continue with a case segmented design. We have done those trade studies in the trades. We believe it is clearly advantageous to stick with a case segmented design, although in a new motor that design may very well be quite different than our present solid rocket motor. For example, the field joints on the new design will be designed such that they naturally tend to close, rather than naturally tend to open.

The second part of your question has to do with facilities. And I appreciate the opportunity to comment to that one because the key to this advanced solid rocket motor program is a facility that is new and has more automation and state-of-the-art in the processing of the motor as it is manufactured. The safety of the solid rocket motor will be put into it not in flight, but in that facility.

There are a number of things that have driven us as we looked at the facility and what the requirements are. For example, we believe that if we are going to build a new facility, not only should it be modern, but we think that it should have water access to Cape Kennedy as well as real access.

Another particular thing that we have looked at is that in this new facility, we think that we should be in a good position if for any reason in the future we had to recompetite the contract, and that drove us to begin to look at facilities that were government-owned and contractor-operated. We have a great deal of experience with facilities such as this. For example, the new orbiter is being built in a GOCO plant in Palmdale. Our plant, our computer facility, in Slidell is a GOCO plant. Our external tanks in Michoud are being built in a GOCO plant, and et cetera across NASA's work.

So, even though we have not presented to the Congress, which we are going to do on the last day of this month, the required comprehensive acquisition plan—and those final decisions are being made—certainly there are strong points in favor of a GOCO plant.

The final part of your question had to do with what sites are being looked at for such a plant. And we principally are now looking at four sites. One has a number of disadvantages. It is at Vandenberg Air Force Base, but we have considered that. And the disadvantages simply are the topography out at Vandenberg, the fragility of the environment and the distance from the Cape.

The other three site locations that are being considered is one at Kennedy Space Center, or at Cape Canaveral Air Force Station in Florida, adjacent to the launch site itself. The other two are the National Space Technology Laboratory in Mississippi, and there is a final site that we have considered which is an abandoned TVA nuclear facility in north Mississippi connected by a waterway down to the coast and then to Cape Kennedy called Yellow Creek, which is in northeast Mississippi.

Senator RIEGLE. I take it that there is a strong base of support in the solid rocket motor industry for a GOCO. Is that a fair statement?

Admiral TRULY. Yes, sir, that's true. Of the five contractors, the inputs that we have received were that four of the five were in favor of the government-owned and contractor-operated approach. And so, it is receiving serious consideration.

Senator RIEGLE. You said four of the five. What was the exception?

Admiral TRULY. Morton Thiokol was the fifth contractor, and they proposed to build the plant, still in a modification, but still a new facility, at their Wasatch facility. And we are taking that also into consideration.

Senator RIEGLE. Let me now call on Senator Pressler, and then after Senator Pressler, Senator Danforth.

Senator PRESSLER. I hate to go ahead of the ranking republican member of the full Committee.

Senator RIEGLE. No. I've already chatted with him. This is a three-corner pass here.

Senator PRESSLER. Mr. Chairman, I want to give part of my opening statement and then ask several questions, and I will take about 10 minutes, if I could.

Senator RIEGLE. Please do.

OPENING STATEMENT BY SENATOR PRESSLER

Senator PRESSLER. Mr. Chairman, today the subcommittee obviously is meeting to consider NASA's fiscal year 1989 budget in this hearing. And by the way, I apologize for being late. I serve on five committees spread around various buildings here and I am trying to keep commitments to several hearings that are being held simultaneously.

Mr. Chairman, it is worth noting that within the span of just seven days two very significant events occurred that could have an important bearing on NASA and our national space program. On February 11, the President announced a new national space policy which for the first time establishes a comprehensive policy for all sectors of our space program, civil, national security and commercial. This policy is also noteworthy in that its goals provide each of the space sectors with a clear sense of its respective role and responsibilities.

Surely some people may be disappointed that these goals do not call for a specific mission on a specific timetable. And that is something that I have been very concerned about because I feel that to attract the right engineers, NASA should have a timetable, a goal, even if it is 1996 or 2000. Because NASA scientists and engineers earn less than they could in private industry we should provide some other incentive, such as a goal. Furthermore, I have been very concerned about the retention of top level people at NASA. Establishing a goal would help retain the top-level scientists and engineers.

Yet, it is by no means insignificant that this policy clearly stakes out NASA's field of play as that frontier beyond earth orbit into the solar system. Furthermore, the policy endorses the advanced technology program, Project Pathfinder, which will serve as the underpinnings of our future space leadership initiative.

One significant message that this new space policy conveys is that a permanently manned Space Station remains as the critical link to our future in space. Without a space station, this new policy will have little, if any, meaning. For this reason Space Station funding in this and the future budget takes on an unparalleled importance. If the Space Station program is forced to limp along, any attempt to regain our leadership in space will proceed at the same pace. Furthermore, we will see many more U.S. companies sign up as Soviet Space Station customers.

The second event that occurred within these seven days was the submission to Congress of a budget request that reflects more growth than any other NASA budget request in 20 years. This request of \$11.49 billion restores balance and vision to our space program. Moreover, this budget request is designed to propel NASA beyond the shuttle recovery period into a well-earned period of challenging scientific and technological endeavors that will help lay the foundation for our space program of the 21st century.

In spite of these two positive events, the news is not all good. Based on last year's budget summit, the Federal Government remains under considerable pressure to limit outlays in fiscal year 1989. NASA will surely feel this pressure. It is both unfortunate and ironic at a time when NASA has received its most encouraging budget request in years, it is also confronted with its most severe budget challenges.

And anyone in this room who is familiar with our budget, authorization, and appropriation processes, which is a three-track process, may agree that we should go back to the old two-track process or even a one-track process. But in any event, that will not happen this year, nor probably ever.

But on a more positive note, NASA and the administration are to be commended for the three new starts in this budget. I have already mentioned the importance of Project Pathfinder. A second new start, the advanced solid rocket motor, will provide needed upgrades to the shuttle's performance and reliability.

Finally, the advanced X-rays astrophysics facility, once deployed and operating, is destined to rewrite certain chapters of our astronomy textbooks. I do not have to understand the fundamentals of X-ray astronomy to appreciate the importance that this observatory will have on our understanding of the universe and its origin.

There are a number of other programs that have benefited from this budget request. Funding for aeronautical research and technology reflects growth that should help restore our Nation's aeronautical, technological competitiveness. Funding for expendable launch vehicles demonstrates that NASA is on its way to implementing a flexible and resilient mixed fleet.

Finally, the budget request for space sciences and applications is indicative of a thoughtful and balanced approach to maintaining a critical number of flight projects and restoring our space science research capabilities.

There are, however, certain issues that remain of particular interest to the committee. For instance, what is the appropriate action, if any, to take concerning the development of a heavy lift launch capability? What is the appropriate division of responsibility between NASA and the Air Force for such a capability?

Another area of this committee's interest is that of insuring that NASA is able to attract and maintain the right mix of qualified scientists and engineers, as I've mentioned earlier, particularly in an environment in which most agencies are constrained by a hiring freeze. How do we, in fact, plan for and execute the most exciting and advanced missions of the future if NASA does not have adequate personnel resources. These are but a few of the issues in which this committee must have an interest and take action.

And I am very pleased to see my friends here, Dr. Fletcher, Deputy Administrator Dale Myers, and the Comptroller, Tom Campbell.

And with that I would like to turn to some questions that I have.

First of all, we have covered many points already. But let me start by skipping over some of my earlier questions and ask this about the \$88 million request. I understand that \$27 million of the \$88 million requested for the advanced solid rocket motor program is earmarked, as has been mentioned, for the study of the government-owned, contractor-operated solid rocket motor facility to be constructed by NASA. How specifically will this \$27 million be used? To what extent is this consistent with the administration's policy toward utilizing the private sector? What priority is NASA placing on the funds now earmarked for the study of a proposed GOCO facility?

Dr. FLETCHER. Senator Pressler, I will start. I think we do have a decision to make shortly—and it will be made in the next two weeks or so—between a GOCO facility which is greatly preferred from the point of view of the safety and the improvement and reliability of the advanced solid rocket motor, but on the other hand, there have been proposals to privatize this in light of the President's new space policy. And so, we really have to balance the privatization initiative with the very stern requirement for high reliability and in a government-owned, company-operated facility. Admiral Truly will give you the pros and cons of those two arrangements.

Admiral TRULY. Yes, sir. Your question was about the portion of the advanced solid rocket motor in the 1989 request, which is \$27 million for the facility. I would point out that that is not study money. That is initial design and that is the first of a total of about \$200 million that will be required to build the facility itself. And the size of that request is based—in this budget is size based on the assumption of the government-owned and contractor-operated facility.

Senator PRESSLER. How will that work out? If it's government-owned and contractor-operated, what would be the procedures used to select the contractor?

Admiral TRULY. The government-owned and contractor-operated, or GOCO, facility is one that we are quite familiar with. We build a good bit of our critical manned space hardware in facilities that are GOCO today, for example, the external tank, the new orbiter, et cetera.

The facility itself is designed by the contractor, not by the government. It is built by the contractor, and then the contractor, whoever the contractor is from the competition, essentially inhabits the facility, and it literally operates it. So, if you drove up to the parking lot, and went into the facility, it wouldn't be obvious to you that it is government-owned.

But there is a tremendous cost advantage of the life of the program, and even though it has the negative of the up-front building costs, it has a tremendous over the life of the program. As a matter of fact, it pushes three to one in total dollars because you don't then have to amortize the facility as you pay for whatever the produce is. In this case it would be the advanced solid rocket motor that would be built in that facility for the life of the shuttle program.

Senator PRESSLER. There has been considerable discussion about the need to modernize solid rocket motor manufacturing facilities. What is your view of the types of modernized facilities that are needed, and are there private contractors willing to make investment necessary to satisfy the modernization requirements deemed essential?

Admiral TRULY. We do think that a modern facility is required, and it is principally for two reasons. One, our present solid rocket motor industry is—and in the case of us, we are building motors solid rocket technology that is really not state of the art. And particularly in the shuttle program, we believe that we can make significant improvements. The type of work that a solid rocket motor production is what we call process related—in other words, adhesives, insulation, the mixing of propellant, the kinds of things that is to maintain control of the process. And one of the ways you do that is with automation, with cleanliness, naturally with training of people.

We are working with the contractors, and I believe that even though I feel that there are strong advantages to a GOCO facility where, as I described earlier, I think there are productivity enhancements that we would pursue in the competition that would make it very inviting to the contractor to invest in new technology and automation. And that is something we'll be exploring as we move forward with the program.

Senator PRESSLER. What would it cost NASA to develop its own solid rocket motor facility, and would these costs be shared by any other agency or by the contractor? Have you verified the reliability of these GOCO development costs? For a contractor that owned his own facility, would we expect his costs of building his facility and providing the tools to be passed on to the government? Is there any economic advantage to a GOCO approach, and if so, how much?

Dr. FLETCHER. Senator Pressler, I would like to start off with that.

We have made estimates, of course, but those are only NASA estimates. We would have to have the contractor bids to be sure. But the estimates that we have—and Mr. Campbell can back this up, if he would—are that the facility itself would cost about \$200 million if it were a GOCO facility. And you would have to add to that something like \$65 million for new tooling and things of that sort. So, maybe \$265 million altogether for the facility.

The cost of the development, of course, will depend on the contractor. We figure that to be just under a billion dollars total. However, it may be that we will get proposals from the contractors which will reduce that amount. So, these are only ball park figures at the moment.

Senator PRESSLER. Now, concerning the advanced X-ray astrophysics facility what are the expected development costs? When is it scheduled for launch and aboard which vehicle? And will this be developed so as to be compatible with the shuttle and an expendable launch vehicle, and if not, why?

Dr. FLETCHER. Senator Pressler, the run-out costs for the development of the advanced X-ray astrophysical facility, AXAF—

Senator PRESSLER. That's a mouthful.

Dr. FLETCHER.—will be on the order of \$1.5 billion. Of course, again, that would have to be refined when we get contractor estimates. We are not starting the competition yet.

It will be available to be launched on the Space Shuttle. It could I suppose be launched on an expendable launch vehicle, but it is not now designed to do that. And so, expectation is that it will be launched on the Space Shuttle. Remember, this is a man-tended facility and it has to be serviced from time to time. The servicing could be by either the Space Shuttle or by the Space Station because the time frame in which it will be available is in the mid-1990s. The estimated date for completion of that is 1995. So, it could be tended by the Space Station as well as the Space Shuttle.

Senator PRESSLER. I understand that NASA requested \$145 million for Shuttle C in its original budget submission. How much is in the fiscal year 1989 budget request for Shuttle C, and how will these funds be used?

Dr. FLETCHER. Senator Pressler, there really isn't money available in the Shuttle C in fiscal year 1989. There was money in fiscal year 1988, study money to see whether the Shuttle C could fit into NASA's long-range plans for transportation. Instead, in fiscal year 1989, we and the Air Force are putting in money for the advanced launch system, which is available at a later date, probably the late 1990s. Both of us have put money in our budget in fiscal year 1989 for that system.

The Shuttle C we felt that we had to cut back on our total request, which as you described earlier is substantial, in order to make room for the other programs. So, the ALS for the moment at least will have to be the heavy lift launch vehicle of the future.

Mr. Myers may want to add to that because he is in the middle of negotiations on the ALS.

Mr. MYERS. Well, actually what we have done is included the Shuttle C in the overall considerations of the future advanced launch system for the country. And NASA and DOD are involved together in developing a strategy for that future launch vehicle. We are planning to complete a study on the Shuttle C to get good cost data and good information on the response times and so on and how it would fit into our facilities at the Cape and on the west coast to be then considered in this overall ALS program.

Senator PRESSLER. I understand the ALS program is a joint NASA/DOD program.

Mr. MYERS. Yes, it is.

Senator PRESSLER. Let me just ask a couple of questions about that. I have some more questions for the record, but I'll then yield.

Does NASA have any requirement for an ALS in the late 1990s and, if not, what are the likely NASA uses of such a capability? And following that up, has the ALS program evolved from a vehicle development to one of technology development? If so, why and what are the implications for this change in character of the program.

Dr. FLETCHER. Senator Pressler, NASA has a lot of uses for the advanced launch system, not all of which are funded at the moment, but nevertheless, to pursue some of the initiatives, for example, that Sally Ride in her proposal suggested, such as some of the large remote sensing facilities required for the visit to the planet earth, as she called it. Also, some of the planetary missions that she envisioned would require an ALS. And we full expect that some of those planetary missions will be carried out.

In addition, however, it is important to point out that any of the initiatives that involve the expansion of human presence into the solar system—for example, return to the moon, establish a base there, or a flight to mars with astronauts—would require many flights of that advanced launch system. And that is perhaps the main emphasis that NASA feels should be put on that advanced launch system.

Senator PRESSLER. Thank you. I have some more questions for the record on that.

But let me ask you some questions in the personnel area. And let me say that I personally think this is one of the most critical areas for NASA.

I understand that due to the fiscal year 1988 actions, NASA's salaries account is underfunded by \$42 million, and that NASA does not have the legislative authority to transfer funds from its other appropriations accounts to compensate for that shortfall. What are the implications of this shortfall in funding for the agency and for the shuttle flight schedule? How do you intend to deal with this problem, or are there possible solutions in the horizons? If so, what are they?

Dr. FLETCHER. Senator Pressler, you put your finger on the most difficult problem we face in fiscal year 1988. And \$42 million was cut out of our R&PM budget, and that was absolutely required to go ahead with our augmentation. And we really need those people in order to keep the flight rate that Admiral Truly described earlier. We urgently need that \$42 million.

Unfortunately, no transfer authority was given in last year's bill. And so, we need additional authority to transfer funds from the R&D budget into R&PM. We expect one way or the other, either initiated in Congress or initiated from us in the next two or three weeks to put forth a supplemental to the fiscal year 1988 budget that will allow us to bring on board those people.

That doesn't end the problem, though, because we need people again in fiscal year 1989. And we have requested in the fiscal year 1989 budget an additional 525 people, which is only a small part of what is required because you have rightly pointed out NASA is people, and to do these programs requires additional people. But nevertheless, the 525 plus the transfer authority in 1988 would put us on the right track. It still doesn't get us enough for the Space Station, and we will have to argue about that sometime later this spring. But we do need additional people. You're absolutely right.

Senator PRESSLER. Now, in the fiscal year 1988 budget request NASA requested an additional 625 personnel. How many of the 625 have you hired or intend to hire? By not being able to hire all the 625 requested, how has NASA been affected? Which programs have been affected most severely?

Dr. FLETCHER. Well, I would have to defer to Dr. Hinners who has kept track of all of the programs that are in trouble. But I can point out some of the highlights.

The biggest problem which we had to deal with immediately was the problem of the launch crew at the Cape. We just did not have enough people down there to—we had enough for the first flight, but we had to turn around that first flight so we could launch it again on either the fourth or the third flight. I've forgotten which. And we didn't have enough people to do that.

In addition to that, we had to have people that worked on the third orbiter. There was nobody paying attention to the third orbiter. We have three of them now. And we had to do something urgently. So, about two weeks ago, we just bit the bullet and gave them authority to start recruiting an extra 90 people. Well, that gives us a shortfall towards the end of fiscal year 1988, so we do need to make that up.

I was just handed a note by my comptroller saying that an urgent supplemental was signed on March 17. So, we are on track for that. I should have made that clearer.

But beyond the launching of the Space Shuttle, the next place that we need people is for the Space Station. We have got our organization in place in headquarters. The facility at Reston is in place. The contractor is on board, but we need the additional people to begin to deal with the Space Station. And those people are still critical in 1988 and again critical in 1989.

But you could keep pursuing that right down through all the various centers. We are short-handed at the Goddard Space Flight Center in terms of handling all the science programs that have to be dealt with next year when we get going again with the Space Shuttle. So, I would say it's across the board that people are needed.

And Dr. Hinners, do you want to add to that?

Senator PRESSLER. And also, the fiscal year 1989 budget request supports the addition of 525 new people.

Dr. FLETCHER. Yes, 525 people in the fiscal year 1989 budget. It was for continuing the launch rate of the Space Shuttle—that is, 2 in this calendar year and 7 again in next year, and then on to 10. We can't keep that flight rate up without that additional 525.

What is missing is the additional people for the Space Station, and we hope to at least have transfer authority later in the spring for the additional people required for the Space Station.

Dr. Hinners is now at the table and he will respond more precisely.

Dr. HINNERS. I would just add, Senator, that with the current hiring freeze, we are now below what we had planned at the beginning of the year. And the projection would take us probably several below by the end of the year if we don't relax that freeze. As Dr. Fletcher noted, we have relaxed it for the Cape for those critical hires, and are looking at several other relaxations for critical hires. But if the transfer language in the urgent supplemental gets approved, we will relax the hiring freeze and get on with our critical hires and get staffed again.

This is a critical time of year for our staffing. It is important that now we make the offers to the students who are going to be graduating from college, and they are getting their competing offers now. So, there is an urgency to getting this issue resolved and getting our hiring back on track.

Senator PRESSLER. How do NASA's salaries compare to those offered by private industry.

Dr. HINNERS. There are some statistics that we are gathering now, Senator. We can demonstrate that in the entry pay our ability to make an offer is about now running \$6,000 to \$8,000 below a comparable industry offer to the engineering graduates. And we can demonstrate that.

We are also having a problem at the high end in that our most seasoned people, those with the experience, indeed are being lured out to industry and encouraged to retire as soon as they can for offers that range anywhere from \$20,000 to \$40,000 to \$50,000 higher than they are making on a government salary.

Senator PRESSLER. As I understand it, after civil servants earn five years of Federal service, they qualify for some type of Federal retirement. But don't civil servants have to wait about 20 years to receive these benefits?

Dr. HINNERS. That has been under the civil service retirement. That, indeed, has been the case. One must wait generally till at least age 55 to retire. The new FERS system, as it is called, is going to change that because it will allow people to walk away immediately at any time with a government retirement benefit to be collected at a later date. But they won't have the hold—or the government won't have the hold on those people for a long-term career.

We are working on, as you may be aware, an alternative personnel system with the OPM which we think will alleviate some of the problems and give us the ability to set entry pay within a band rather than being limited by the very rigid GS structure that we are compelled to live with. We expect that to be forthcoming soon.

Senator PRESSLER. I want to ask one other question.

There has already been some discussion about a commercially developed space facility. According to the national space policy and the recently released notice in Commerce Business Daily, NASA will be an anchor tenant in a commercially developed space facility, CDSF, which

will be available no later than 1993. Furthermore, as an anchor tenant, NASA will be expected to provide from \$400 million up to \$700 million in lease payments. Do these payments reflect the actual value of the services to be rendered or were they chosen arbitrarily?

Mr. MYERS. Senator Pressler, the idea of the ISF had been developed in the commercial industry over a period of about six or eight years. And they had an agreement with us that we would launch them commercially with their having developed and made available this device. They expected to sell space to commercial customers and have us launch them. And we had an arrangement where we would put them on the manifest and we would charge them for the launches, and that was the agreement we had.

Unfortunately, after the Challenger accident, commercial people in the drug industry and in the electronics industry withdrew their sort of speculative investment in these areas because of the long duration of time before they would be able to launch. And it was decided in this economic policy council that it be worthwhile trying to encourage the industry to get back into this business. When the idea came about of us being an anchor tenant in a device financed and built by industry, it became clear that we were going to be putting money into it. So, we decided that we would go competitive in the operation.

We have now under way the development of a request for proposal where we would be asking industry to finance, design, develop and make available a facility that we could launch on the shuttle. We would start leasing the facility in the 1992-1993 time period for a period of five years.

The amount of money that was estimated based on some earlier inputs that we had gotten from industry and had made ourselves about the kind of commitments that you would have to put into a program of that nature to cover the cost of money, the profits for the industry and the development costs to make the program available.

And we are looking for industry's inputs in this. We have put out a statement of work to industry to get their inputs on what they thought might be required. We have a draft RFP that we are putting out to industry, and we are getting feedback from the industry on this. And we'll have a better answer to that question when we put out the RFP at the end of this month. In fact, the real answers will come when we get real proposals from the industry for this lease activity.

Senator PRESSLER. Thank you very much. I have some additional questions for the record.

Let me say that I think you folks are doing a terrific job under what has to be very difficult circumstances from an administration point of view. There are many uncertainties, with which you must deal, such as the political factors, the three tracks of our budget process, and the last year of a presidential administration.

Although we are starting out good here today, I think that before the year is over, there is going to be much more debate. I just hope it doesn't hurt the moral of the people who work at NASA. But I foresee a difficult year. I hope it doesn't turn out that way. We will certainly take every step we can to help.

Thank you very much, Mr. Chairman.

Senator RIEGLE. Thank you, Senator Pressler. I think those were very good questions, and I think they really helped to build our record here.

As a follow-up to Senator Pressler's personnel questions, is OPM considering a China Lake type personnel system for NASA?

Dr. FLETCHER. I will ask Dr. Hinners again to comment. But China Lake was a good experiment, and it allowed a flexible salary structure and also put the onus on management to promote people when they deserved to be promoted, but not promote them when they did not deserve, which has been a defect for a long time in the civil service system.

We have under consideration a similar proposal for NASA, which has been brought to the attention of OPM, and actually they have signed up for informally. And I think Dr. Hinners is pressing on that. I don't know the status of it at the moment.

Dr. HINNERS. We are working right now with OPM jointly with the Department of Defense to develop language to submit to the Congress proposing an alternative personnel system.

Senator RIEGLE. So, you actually are drafting a proposal, and you are going to send us one here?

Dr. HINNERS. That is correct.

Senator RIEGLE. Do you know when?

Dr. HINNERS. I can't give you an exact date on that.

Senator RIEGLE. So, it is moving actively.

Dr. HINNERS. Yes.

Senator RIEGLE. Admiral Truly, let me go to expendable launch vehicles. The 1989 budget request contains almost \$200 million for expendable launch vehicles and for launch vehicle services. Can you tell us what mix of launch vehicles would be provided if this request were approved?

Admiral TRULY. Yes, sir. The money in fiscal year 1989 initiates the real meaningful start of the mixed fleet, the balance of space transportation with the shuttle and the ELVs. The dollars that are in the fiscal year 1989 budget include start-up dollars for two Delta ELVs, two Titan IIIs, a Titan IV as an alternate planetary vehicle, and two Scout expendable launch vehicles. And also, sir, it continues two other Deltas. A portion of the Deltas are a continuation of the two that are funded start to be funded in the fiscal year 1988 budget.

Senator RIEGLE. Do each of these launch vehicles have assigned payloads and proposed launch dates now?

Admiral TRULY. Yes, they do.

Senator RIEGLE. Can you give us those? I mean, if you don't have them right handy, can you give them to us for the record?

Admiral TRULY. Yes, sir. We do have them, and I'll submit that for the record.

Senator RIEGLE. Very good.

[The following information was subsequently received for the record:]

The two Delta vehicles being continued from the FY 1988 budget are for Roentgen Satellite (ROSAT) in February 1990 and Extreme Ultraviolet Explorer (EUVE) in August 1991.

The vehicles being started in FY 1989, their assigned payloads and launch dates are:

<i>Vehicle</i>	<i>Payload</i>	<i>Launch Date</i>
Titan III	Tracking and Data Relay Satellite (TDRS) Callup	August 1991
Titan III	Mars Observer/TDRS Callup	September 1992
Titan IV	Alternate for Magellan, Galileo or Ulysses	May 1991
Small (Scout) Class	Chemical Release and Radiation Effects Satellite (CRRES)-1 CRRES-2	November 1989 March 1991
Medium (Delta) Class	GEOTAIL WIND	July 1992 June 1992

Senator RIEGLE. Can you tell us what the total cost of these vehicles is and over what period of years the payments would take place?

Admiral TRULY. The run-out cost for each of them—and let me just run down this quickly. The Delta II for the ROSET mission is about \$46 million. The Delta II for the EUVE mission is about \$39 million. The Titan IV cost for the alternate planetary is about \$160 million. The Titan IIIs run out to about \$180 million. And the total Scout run-out is \$104 million.

Mr. Chairman, the other portion of your question was over what period of years do these ELV run-outs go. And some of them go out to 1993.

Senator RIEGLE. Very good.

Let us now move into the space science area, and I would like to ask Dr. Fisk to join us at the table. Thank you, Admiral Truly.

I understand, Dr. Fisk, that up at the field hearing Boston on March 7, that you were a sensation, and they are still buzzing about it. I understand you got an ovation from the crowd, and that is no small feat. John Kerry has reported that to me, and he'll be here later. He is now leading the fight for AXAF. So, in any event, let me welcome you to the table.

I want to run through a series of questions with respect to space science and applications. Let me do so.

The 1989 budget for the Office of Space Science and Applications is \$1.86 billion compared to an fiscal year 1988 appropriation of \$1.575 billion. So, this represents an 18 percent increase in terms of the request.

What are the most compelling reasons why this subcommittee should approve the budget request for the Office of Space Science and Applications?

Dr. FISK. Well, I think there are a couple ways to answer that. It is a budget which preserves and enhances U.S. leadership in space science. Like much of the rest of the NASA budget, the great majority of that increase is simply to do what we have already agreed to do in the past. It completes the ongoing program. And, of course, the converse of that statement is also true. If we fail to provide an increase of that magnitude, then there is a serious disruption on the ongoing program and a disruption in the leadership and a disruption in our ability to maintain leadership in space.

Senator RIEGLE. Let me ask you this. What programs were deleted by OMB in the pass-back for space science and applications? And what programs did NASA appeal?

Dr. FISK. There was a deletion of the CRAF and the AXAF program, and NASA appealed the AXAF program.

Senator RIEGLE. If the subcommittee froze spending for fiscal year 1989 at the 1988 level, what would be the impact on the space science and applications program and the space science community in your view?

Dr. FISK. It would be a devastation. I mean, basically if it was really frozen at the 1988 level, I think we would have no choice but to delete major flight programs, possibly in the neighborhood of two or three. And the devastation that would result would be very large. I mean, as you now, 1989 is a year that we begin to fly again. And so, it is a year that we are looking forward to as one of getting the program back on track. And, of course, then to have serious setbacks result in the program because of the lack of funding would be a devastation to the community.

Dr. FLETCHER. Mr. Chairman, I might just add one thing. I know you understand this, but for the group here, we have already invested a lot of money in some of the space science and applications programs that are going to be flying in the next year or two. For example, the Space Telescope is \$1.5 billion program. The Galileo is probably comparable. You can't cut those out to save \$100 million to cancel \$1.5 billion program. It doesn't make sense. The GRO is well along, and so there are a lot of those space programs that are almost paid for. And you have to keep them alive. And so, to cut back or to cancel a program that you have made that much investment in doesn't make sense.

Senator RIEGLE. Well, fiscal year 1989 is really our critical year, is it not? As you have touched on some of the items, we are anticipating the launch of the Space Telescope, the Magellan, Galileo, COBE and the Voyager fly-by of Neptune. It sounds to me like a tremendous amount of work is really about to culminate here. And there is an awful lot riding on it, both for space science and just in terms of resources over a period of time.

Dr. FISK. There is, indeed. In many ways, 1986 was to have been a very exciting year for space science which got derailed on January 28. We have had essentially a three year hiatus in the program, and we begin again in 1989.

Senator RIEGLE. How would you describe the overall status of U.S. space science and application programs? And is the United States still perceived as a world leader in this area?

Dr. FISK. I think it can be. Basically I think people are skeptical because we are on the ground. We have the best space science program in the world on the ground at the moment. If we are able to fly it and begin to realize the potential of all of these missions that we have under development, I think we will reassert our leadership very quickly.

Senator RIEGLE. Despite the significant number of space science payloads that are scheduled for launch in the 1989 to 1992 period, there is a significant decline after 1992 that runs until 1995 and beyond. Can you shed some light on that gap? Are there remedies to it?

Dr. FISK. Yes. Basically by 1993 all of the ongoing programs will be launched. There are something like 20 missions between now and 1993 representing both the backlog and the missions that are under development at the moment. But what we require is the regular succession of new starts each year so that we then have a regular succession of flights. The new start that we have under request for this year is AXAF, as has been discussed, and basically it is crucial to begin that in 1989 so that by the time you get to 1994 and 1995, we have an ongoing space program.

Senator RIEGLE. What do you see out there? What are some of the major candidates for new start status?

Dr. FISK. Well, beyond AXAF, which is the 1989 request, we have under study a cometary mission. We have under study an earth-observing system as part of the sort of base program for earth science and as a precursor to the mission of the planet earth. Those will be in future budget years.

Senator RIEGLE. Let me ask you about the Explorer program. The program received an augmentation by Congress in 1988, and NASA requests another increase in 1989 for these smaller scale lower cost, but still very good science missions. Can you tell me how the fiscal year 1988 augmentation was used by NASA and how many approved payloads are still awaiting flight opportunities?

Dr. FISK. Yes. The fiscal year 1988 augmentation, which was provided by Congress, was very welcome to us because the Explorer program suffered quite a setback as a result of the Challenger accident. The COBE mission, which is to be one of our first launches in 1989, was originally scheduled for the shuttle and had to be reconfigured for a Delta launch. And that was a very expensive operation. That came from the Explorer program and had the consequence of delaying future Explorer missions. And so, the \$10 million augmentation in 1989 was applied primarily to be able to reaccelerate to bring forward those future missions, thereby providing new Explorer opportunities out in the 1990s.

The Explorer missions under development at the moment are EUVE, the extreme ultraviolet explorer, which is a launch in 1990, and following that would be the XTE, the X-ray timing explorer, which would be launched in about 1993 or 1994. The \$10 million augmentation in 1989, \$10 million on top of the \$10 million the Congress provided in 1988, is to be used to open up a new class of Explorer missions, the so-called Scout class.

One of the concerns we have, like Senator Bentsen, is over the education of the next generation of scientists and engineers. And we are anxious to provide some missions which are sufficiently small—capable, but small -- that universities can get their hands around and also NASA centers can get their hands around to do in-house which will provide an opportunity for the training of the next generation of scientists and engineers.

As you noted, in Admiral Truly's comments there are Scouts to be purchased as part of the ELV plan. And that is a coordinated program between science and the Office of Space Flight. And we will have Scout class missions available for launch in 1991.

Senator RIEGLE. In terms of the suborbital program, has NASA made a significant effort to expand this program in order to give graduate students and researchers greater flight opportunities?

Dr. FISK. We made a significant effort to expand the program in general while we have been down and unable to fly in space. This is one of our principal activities. And so, the vitality program, which NASA established in 1987 following the Challenger accident, was to essentially divert funds into those areas which would have most effect in providing near-term research opportunities while there were no missions being launched on the shuttle.

A lot of those funds have gone to the suborbital program, and we have used them, for example, to conduct the Super Nova campaign which is primarily a suborbital program activity. We have conducted the ozone campaign as a suborbital program activity. And those have provided expanded research opportunities and as a result, there are extra opportunities for graduate students to participate.

Senator RIEGLE. You know, I am finding in the Senate and I think in the country generally that the focus on the ozone problem is of enormous interest. I mean, it is just an explosive interest. And it would seem to me that it's a natural opportunity for the NASA programs to really give some leadership.

It is interesting. I've been talking with dermatologists in Michigan particularly about the tremendous increase in skin cancers arising in a younger and younger population. The sense is that there is a connection between these things. I don't know the degree to which there is or isn't, but that certainly seems to be a reasonable hypothesis.

How much more might we be able to do in the ozone area if we were to really zero in on that?

Dr. FISK. Well, I think there are a number of activities under way that you should be aware of. And, of course, we conducted, along with the NSF and NOAA and the Chemical Manufacturing Association, this ozone campaign in Antarctica which provided quite definitive measurements of the cause of the cause of that activity. The upper atmosphere research satellite, which is an ongoing NASA flight project which is one of those programs which experiences growth between 1988 and 1989, is to provide definitive measurements of the ozone and upper atmospheric chemistry. And that is its principal purpose.

And the suborbital program provides measurements of those activities. We have discussions under way as to how we might fly additional TOMs which an ozone mapping experiment. And basically we consider it our responsibility to provide research measurements to do research on the upper atmosphere and on the earth from space. And there is a number of activities under way.

Senator RIEGLE. What is the current status of the Magellan program, and are there any possible problems that could impact the scheduled launch of this mission next year?

Dr. FISK. It is on schedule for launch in April of 1989. The only current threat which does not appear to be a very serious concern is we are awaiting the availability of what is called a thermal vacuum chamber at the Martin-Marietta Corporation. The current occupant of that is on schedule and should be out in time. And as long as that occurs, we see no difficulty in making the launch.

Senator RIEGLE. How long is that launch window?

Dr. FISK. It is approximately 20 days.

Senator RIEGLE. And if you miss that, when would the next one be?

Dr. FISK. The penalty is very severe. It is in excess of 20 months.

Senator RIEGLE. And there is nothing more that needs to be done right now to make sure we hit that window?

Dr. FISK. No. You may have noticed in the 1988 operating plan that we diverted from other flight projects some sums of money into the Magellan program to keep it on schedule because it is our highest priority in getting off on time. And we believe we have put an adequate amount of funds into that program at this time.

Senator RIEGLE. Now, the Mars Observer program scheduled for launch in 1992 still has not been baselined for the Space Shuttle or the Titan III. What space vehicle or what launch vehicle would be the preference of the Office of Space Science?

Dr. FISK. It would basically be our preference for Titan III. I mean, you can launch it adequately on the shuttle. The ELV plan, which has been submitted as part of the 1989 budget, includes funds for the purchase of a vehicle which could be used for Mars Observer on a Titan III.

Senator RIEGLE. And in terms of which option is the least expensive?

Dr. FISK. Well, I think to some extent it is expensive to whom. From the perspective of the Office of Space Science, it is less expensive for us to fly on a Titan III. I assume that, however, there has to be a purchase of a Titan III. And, of course, then you also have to ask can that shuttle flight be used by someone else if it is not on the shuttle. So, it is a complicated set of economics, but from my parochial point of view, there are advantages to Titan IIIs.

Senator RIEGLE. The Galileo mission to Jupiter in 1989 and the Ulysses mission to the sun in 1990 require nuclear generators. This represents the first time such generators have been launched on a manned vehicle, namely the Space Shuttle. Has a thorough risk assessment of both these missions been initiated? And what is the proposed timing to seek a presidential waiver to launch these payloads?

Dr. FISK. That analysis is under way. We are working closely with the Department of Energy, which has responsibilities in this area. We have an advisory committee that we appointed of external people to review our activities. The schedule is tight, but it is a very doable schedule. I suspect that the actual launch waiver will be issued by the next administration according to the timing that we're on.

Senator RIEGLE. Our full Commerce Committee here currently has under way a GAO investigation of four NASA space science missions to try and understand the reasons why these missions have experienced such huge cost increases. And the four, of course, are Galileo, Ulysses, Magellan and Hubble space telescope. Can you explain to the committee why such costs increases occur?

Dr. FISK. The bulk of those cost increases are the result of launch slips. I mean it is simply——

Senator RIEGLE. Launch slips?

Dr. FISK. Launch slips, the inability to get the missions off on schedule. This is particularly true of Galileo. You will recall that it was originally manifested to fly in about 1983. It was remanifested in 1986, and now it is in 1989. And when you keep the cost of the development of that program going that long, that's the principal cost growth that you encounter. Hubble had separate problems.

Senator RIEGLE. I take it that that is another way too of saying that if we were to have ELVs, we could presumably get things off——

Dr. FISK. That is absolutely true.

Senator RIEGLE. ——and avoid some of that premium cost.

Dr. FISK. It is key I think to being able to run an effective space science and applications program to have assured access to space, and that comes in two ways. That comes in a shuttle launch rate that is predictable and achievable, and it comes in a variety of separate launch capabilities through ELVs.

Senator RIEGLE. That reminds me of a thought that has been in my mind several times and it was as we were going through the Rogers Commission hearings at the time, and that is the phenomenal cost of the Challenger accident. The absolutely phenomenal cost: the astronauts, the loss of the shuttle, the time that it is taking us, all of these premium costs associated with delays. I don't know that we will ever be able to really add up in a dollar sense the cost, not to somehow put that above the human cost, but the dollar cost is really breathtaking. And then if you then loop that back to what everyone concedes was an avoidable accident, the fact that incredible cost, human and financial, was something that we brought upon ourselves by numerous breakdowns that have been well-identified.

But it really illustrates the fact that this balance between good management and good risk assessment versus what are always tight, tight budgets and hard budgets to get money from—mistakes of that magnitude can have a devastating effect on the program for the long, long period of time. It seems to me we are seeing that now, and probably will for many years to come.

Let me go to the new U.S./USSR cooperative agreement. Last April——

Dr. FLETCHER. Mr. Chairman, could I interrupt you, if you are finishing up the space science and applications?

Senator RIEGLE. Yes.

Dr. FLETCHER. I think I need to reemphasize that we can't do all of these things that Dr. Fisk was talking about without an adequate space transportation system, as you properly pointed out. But again, I want to remind you that \$1 billion of the \$2.5 billion request is for that. In other words, if we don't get that money for the ELVs and for the Space Station, we won't be able to launch those payloads that Dr. Fisk is talking about.

In addition to that, we have a lot of the other additional funds that are required to augment Dr. Fisk's program. So, we need a fair fraction of that \$2.5 billion to carry out what Dr. Fisk has been talking about.

Senator RIEGLE. I think that's a very important point.

Let me just go back now to this U.S./USSR cooperative agreement, which was signed last April concerning cooperation and the exploration and use of outer space for peaceful purposes. What progress has been made in the last year with regard to the new agreement? And which of the 16 cooperative projects have received the most attention?

Dr. FLETCHER. Well, I'll start out, Mr. Chairman.

We, indeed, have had active dialogue with the Soviet Union in these 16 areas. The earlier discussions were the planetary panels, and the discussions centered on cooperative activities with regard to the Mars missions, both our own Mars Observer and the Soviet Mars mission to the moon Phobos of Mars which I think the launched is scheduled for this calendar year. And that has come a long way because basically we have agreed to support their Phobos launch with our deep space tracking net. In fact, as I understand it, we will be able to enhance the quality of their—the resolution of their photographs of Phobos by a factor of something like two to three through use of our deep space net.

It has followed on into other planetary missions, and also it includes the beginnings of what we call the mission to the planet earth or the global climate program. And we are beginning to cooperate in that area as well. We haven't agreed to anything in that area, but discussions are under way on how we use the NASA facilities, coupled with ground truth from the Soviet Union, on measuring some of the way forests breathe and things of that sort. Remote sensing is a big part of that global climate program.

So, I would say we have made considerable progress with the Soviets considering we only started about a little over a year ago. And I think that people are warming up to each other and beginning to exchange freely the information, being mindful of the restrictions on technology transfer. So, I would say by and large it is going rather well.

I think there are some discussions that went on last week, but I'm not exactly current on that.

Dr. FISK. Well, basically we met with the Soviets last summer on life science. We met with them last fall on planetary works. We are actually having a visit of the Soviets later this week. They are in this country for various reasons. And we have scheduled in the April/May time frame one on earth science and one on astrophysics and space science. So, there is active pursuits of all the areas that were spelled out in the agreement.

Senator RIEGLE. Let me indicate I am going to adjourn the committee now. We are about to start this veto override vote. And I think the leader has announced that he is going to hold it to the strict voting period. So, I will need to go over there at this point.

We will reconvene the hearing this afternoon at 1:30. Senator Rockefeller will chair the hearing when it opens at 1:30, and then I will be back a little bit later than that.

I want to announce as well that six members of the subcommittee have been at a classified INF briefing this morning and have wanted to be here. Most will be here this afternoon. It's the nature of things around here that we always have multiple assignments going at once.

The committee will stand in recess until 1:30.

[Recess]

AFTERNOON SESSION

Senator Rockefeller [presiding]. Dr. Fletcher, Mr. Campbell, Mr. Myers, I apologize for being a little later. We had a vote and some of us had to get a bite, and I am going to further inconvenience you, because I want to give a statement, which is not necessarily useful for your time, but nevertheless is something that I feel that I should say.

Obviously, I very much welcome this opportunity for our committee to look at NASA's budget and their proposals for the coming fiscal year. I expect this to be a pivotal year for our nation's space program. This should be the year in which we will hopefully leave the Challenger accident behind us, with the successful launching of Discovery this summer. This should be the year in which the country's confidence in the space program begins to be restored.

But even if Discovery takes off in August without a hitch, as I hope it will, all of us here know that there are still some very difficult days ahead for our space program. NASA has told Congress that if we want a quality space program we are going to have to pay for it, and that is as it should be.

Judging from NASA's budget request, quality does not come cheap. The President's request for a 24 percent increase in NASA's fiscal year 1989 budget, a request for almost \$11.5 billion, may indeed be what we realistically need if this country is to be a leader in space.

This authorizing committee has the responsibility over the next few weeks to make a thorough and realistic assessment of NASA's budgetary needs in light of our space program's goals and objectives.

Even if, however, we were to decide that the President's budget request for NASA is the right mix of programs and levels of funding to retain our leadership position, I must be frank: I will be very torn about this budget proposal, and I am sure that I will not be the only Senator feeling torn.

In my case, I represent 1,900,000 people of the state of West Virginia. The people of my state support a strong civilian space program, and so do I.

As the home of aerospace pioneer Chuck Yeager and shuttle astronaut Jon McBride, our sense of pride and even patriotism about the space program remains palpable, strong. Yet it is no secret, I think, certainly not to me, that West Virginia and our nation face tough economic times. It is no secret that we need jobs and economic development in West Virginia.

Dr. Fletcher, you and I have talked before, I think back to the year 1982-1983, when I was Governor of that state and our unemployment rate was 21 percent. That is not much fun. Our unemployment rate still leads the nation, and that is not any fun at all.

And it is also, I would add on top of that, no secret that our nation faces a Federal budget deficit of possibly more than \$160 billion. So if this committee finds that NASA really needs a 24 percent increase in order to keep us in the forefront of space exploration, the budget process for this Senator from West Virginia will be even more difficult.

The administration is proposing a \$2.6 billion increase in budget authority for NASA out of a budget that under last year's deficit reduction summit agreement only is going to provide a total of \$3 billion in outlay increases for all non-defense discretionary spending. So where is the money going to come from?

Will it come once again from rural housing, water and sewer projects, job programs, literacy? West Virginia and our nation cannot afford that entirely.

For example, in West Virginia for over 20 years we have been trying to build a highway segment connecting the northern and southern parts of our state. Each mile of that highway now costs close to \$20 million to build. My people want to get into outer space and they want to get to Mars, but they also want to be able to drive from Charleston to Williamston, West Virginia.

I do not like to think that we must choose between deficit reduction and the scientific and technological benefits that have come from space exploration. We rely so heavily on some of the developments from our space program that they are now taken by us to be commonplace.

Two benefits, Dr. Fletcher, that come immediately to mind are satellite communications, which certainly bring our world closer together, and, two, improved, sometimes lifesaving, satellite weather prediction.

But I realize that our space program has still much more to offer. Our future competitive position in the international marketplace may very well depend on space-related fields, such as microgravity research or computer software.

It is our job, then, as the authorizing committee to make some hard choices and define what the course of the civilian space program should be. It is also our job to search for alternative ways to fund our space program.

Two weeks ago, the President unveiled a plan directed towards the commercialization of space. Frankly, at least from my point of view, the President's program is several years too late. But nevertheless, it is here.

The space program has been operating without any coherent long term policy for at least a while. At a time when the budgetary pie is getting smaller and smaller, we cannot afford to flounder.

There are some good ideas, I would think, in the President's program. I agree that we should at least examine increasing the role of the private sector. I am also pleased to see that the Administration is recommending an 18 percent increase for space science and applications programs. If this country is going to retain its competitive edge, we should not confine our research efforts to planet earth.

We have, I in sum, a long hard job ahead of us. The potential gains to our society from space exploration are mind-boggling. Space activity can greatly expand our knowledge of the universe, advance our technological development, and lead to discoveries with substantial benefits to people on earth.

However, we need to accomplish all of this without somehow abandoning the essential goals that we have here at home. And Dr. Fletcher, I do not know what that combination is. You and I have talked a num-

ber of times in the past. I think you know how strongly I support you on a personal basis and on a professional basis and in the job that you did and are doing at NASA.

And I have not heretofore agonized in the way that I am now compelled to about some of the hard choices that need to be made. It is almost a cliché now in this country to—it is almost too easy, one might say, to look at a Space Station budget which is obviously many billions of dollars and then make a rapid and easy comparison to some housing project or job development project or literacy training project.

And the way that one sets up the question or poses the statement almost makes it impossible for space to come out on top, because the emotional content is usually phrased in the question in such a way that the human element comes out on top, instead of the NASA element.

I only wish to say, Dr. Fletcher, to you, who I so much respect, and to a program which I so much respect, that I think it ought to be this year—it may not be this year; it will certainly be next year—that all of a sudden the era of the fifties, the sixties, the seventies, and the eighties, and the string that carried us through all of that really does come to a halt.

Whoever is elected President next year, will no matter what they have pledged to the public, probably go into a substantial tax raising program, even as we continue to cut the budget. The military has now been for about three years without any real increase, and it gets harder to cut.

It get impossible virtually to cut in the 13 to 14 percent of the discretionary budget that lies outside of national interest payment and outside of entitlements and outside of defense.

So as somebody who comes from a state with massive problems, who cares enormously about the NASA program, who has worried out loud with you, Dr. Fletcher, not only privately but in person, about what I consider the very special role of NASA, who has worried out loud publicly about the DOD budget and the size of it compared to the NASA budget and the size of it, sort of the natural encroachment upon the civilian aspect of all of this, which I so treasure and so prize, but the time and the difficulty of making the choices is getting very hard indeed.

Now, I was not here this morning and there may have been 15 Senators who said exactly that same thing, or perhaps none of them said that. I do not know. But it is something which is going through my mind now, Dr. Fletcher.

It is something that I have to wrestle with as I serve both my people and my country, and as in doing that I am doing one thing.

So having said that, I would like to, put some questions to you which will be reasonably technical, and I thank you for your courtesy in listening through. And you may want to respond, incidentally, to anything I have said.

Dr. FLETCHER. I cannot disagree with you, Mr. Chairman. This is a tough budget year. And I think, however, it is the year in which NASA, with the support of the President at least, has decided to

recover from the Challenger accident and set the course for the years to come.

I think somehow the NASA budget, being one percent of the total, there ought to be some way of financing that. Now, I do not have the easy answer to that question, and I just hope that enough of you get together and solve the nation's problem, which includes space as well as all of these other things that you mentioned.

Senator ROCKEFELLER. And I do, too. And I suspect we will, Dr. Fletcher.

I spent a couple of hours yesterday with the superintendent of schools for California, Bill Hoenig. He is a very bright and able person, and we were talking about education. And it seems that in Congress that, since we do not carry the burden of education financially, only about ten percent or so of it, that we are constantly looking for little new entries, little ways to do little things.

And what he was saying was that, if you want to make a difference in education any more in this country, you have to back away from the entire thing and simply decide that doing education is of sufficient importance that you take \$7 to \$10 billion that you do not have, and you go ahead and allocate it in a coherent way to education.

Now, how could I disagree with that? We do bits, we do pieces, we do demonstration projects. We do something on drugs here, we do something for workplace literacy there. We do something for Headstart there.

But the sort of backing up from the whole process and trying to really pick for what is important for the country, I think that is what you are suggesting that we have to do, that we have been nickeling and diming you, and that you want us to back up and make a major commitment to NASA to get off of the business of trying to decide each year whether or not we are going to go forward.

Dr. FLETCHER. Mr. Chairman, I would add to that, in the sense that it is really addressing the nation's future and at the same time addressing the here and now. We have to do both, and the impact of the space program on the next generation is enormous, particularly in the education field.

If you go around and visit the elementary and secondary schools, as I have, the youngsters all are expecting to have a better world to live in. And to do that we need trained people. We need people that understand math and science, because basically we are a high technology society, whether we like to be or not. That is what we are becoming, and we need those people trained.

And the way to train them is to inspire them by the kinds of things that NASA does. And so if we look to the future, we ought to be investing in space.

And I do not have to tell you about all of the spinoffs that run throughout the economy as a result of the space program. But on the other hand, I agree that you have to deal with here and now at the same time.

Senator ROCKEFELLER. Thank you, Dr. Fletcher.

Let me ask you this. The Office of Commercial Programs is the NASA office responsible for bringing private industry into the space program. Since the President's new policy calls for an increased commercialization and privatization in our space program, why are we cutting this program from \$56 million in fiscal 1988 to \$38.8 million in fiscal 1989?

Dr. FLETCHER. Mr. Chairman, we should have explained that probably in the budget book. But it actually is an increase over last year. There is an artificial amount of \$25 million that was in the commercial space program last year, that was put in by the Congress for the industrial space facility.

And as you know, we are going out in a competitive way for that facility, and so the \$25 million in the fiscal 1988 budget is not in the fiscal 1989 budget.

And Mr. Campbell, I have forgotten how much it actually increases. It is like \$12 million, is it not?

Mr. CAMPBELL. That is right.

Dr. FLETCHER. So it is actually a \$12 million increase for commercial space if you discount the industrial space facility.

Senator ROCKEFELLER. Okay, that is helpful.

In January of this year, NASA opposed leasing the proposed industrial space facility which we have just spoken about from Space Industries. Then in February, after apparent pressure from the White House, NASA reversed its position and came out in favor of a commercial space facility.

Soon after, the Marshall Space Center took the added step of issuing a notice to industry for a commercially developed space facility. The facility specifications issued by Marshall were very similar to those of the ISF. Since NASA intends on choosing a winner for the contract in mid-July, when will Congress see the next budget request for the commercially developed facility?

Dr. FLETCHER. Well, the short answer to your question is that we are still working on it. And Mr. Myers this afternoon and yesterday has been spending a lot of time on that.

But let me see if I can put that question in the proper context. The original arrangement with a company, a Space Industries partnership, Texas-based company, was that we would launch their facility and it would be used by the commercial sector, they would pay for the use of it, and we would be reimbursed for the launch cost from those commercial users.

Well, this arrangement was made, I think, in about 1984 or 1985, and unfortunately we had an accident since then, and for other reasons perhaps, the delays were such that the commercial users apparently did not show up. So the Space Industries partnership came to us and asked if we would support a government use of part of that station.

And at that point, we had to stop and think about it. The money they were talking about was something like \$700 million for leasing a fraction of it, say 70 percent for a five year period.

Well, that meant, if we were going to put up that kind of money—and when I say we, the whole government; we were acting as an agent for the government—we had to regroup and find out just how the government would use that space facility.

Now, that is not an easy job, because basically we are the anchor tenant, so to speak, for the government. We are the main leasor. And yet, we have to provide for the commercial sector, and to do that with an appropriate RFP and make it competitive. A request for proposal is a tricky business, which Mr. Myers has been spending the last several weeks on.

Do you want to tell us where we stand, Dale?

Mr. MYERS. We put together a statement of work. That is a performance type spec. It is basically saying, what do we see as the needs for the government. And we have sent it out to industry for comments.

We have received comments from industry. We have incorporated them into an RFP, draft RFP that we have essentially ready for sending out again to industry for comment. And we look like we are on our schedule, which is a tight schedule, to complete the lease arrangements by this summer.

Now, it turns out that if this thing works the way we hope it will work—and we will be working with Congress on this issue—we would not need to have—we would not be funding the contractor for the development of this facility. What we would be doing is promising with assurance that we would lease it for a five year period.

That would give them enough collateral to go to the investment community and borrow the money to build the facility and make it available to NASA. That is a pure commercial activity based upon us being an anchor tenant to give them and their investment community the assurance that there would be some money coming from the government across that time period.

We do have enough increase in our budget in microgravity and enough increase in interest in the whole microgravity area to make available payloads that could be carried by the CDSF and make it rational that we would lease the facility across that five year time period.

At the same time, we would expect the offeror of the CDSF to encourage the commercial industries to buy space on the facility also. So it would be a mixed payload of commercial and government payloads.

Senator ROCKEFELLER. I am handed a note here saying that the subcommittee has been told by industry that an authorization and appropriation is required if private investors are to provide funding.

Dr. FLETCHER. That is absolutely true, Mr. Chairman.

Mr. MYERS. We think that is true. We think that in order to assure the industry that there would be funds available five years from now, it would appear to us that there would have to be appropriated funds, not outlayed but appropriated, sufficiently to cover termination liability in case, for the convenience of the government, the government stopped the action.

So you have to give the industry some assurance that there will be money available five years from now, or in fact there would be money available for the purpose of termination liability. That does not mean any outlays, but it means money appropriated so that if there was a termination the money could be paid out for termination liability.

Now, that is our view. There may be other ways to do this and we are working within our own activities. We will be working with the Congress on this, on those issues.

Senator ROCKEFELLER. Okay. Now, according again to Space Industries, one of NASA's original objections to leasing the ISF is that a great majority of the materials processing experiments must be man-tended. Since the ISF is proposed to spend most of its time as a free-flying facility, not connected to the shuttle with man-tending, NASA felt that it might not serve the needs of the companies interested in materials processing.

Does NASA still feel this way?

Dr. FLETCHER. Well, I think that it is an oversimplification that states that NASA only has this use or that use. Most of the microgravity users that the government has in mind, these are people from the Department of Energy, people from NASA, people from the National Bureau of Standards, the National Science Foundation, prefer the mode in which the industrial space facility is attached to the Shuttle, and so that it substitutes, if you like, for the Spacelab, because there are not enough Spacelab experiments.

This is the research part of the program, because the government is not involved in commercial activities. A good many of the commercial users that want to actually process materials in space may prefer the free-flyer because you have longer periods of time.

Typically, the space facility would only be attached to the shuttle for ten days at a time or, with an extended duration orbiter, up to 16 or more days, whereas if it is a free-flyer you could have materials being processed for perhaps four to six months.

So the commercial users have a somewhat different idea in mind. However, NASA could also use that long duration period for some of its own experiments, but that is a small percentage of the total and so it is not all black and white.

But nevertheless, most of the uses would be for us attached to the Space Shuttle, a good many of the uses for the commercial sector would be as a free-flyer.

Senator ROCKEFELLER. Dr. Fletcher, do you have or could you send the committee any figures or percentages on the numbers of materials processing experiments which require man-tending?

Dr. FLETCHER. We can supply that. I went through that with—Jim Rose is here, and he is the director of commercial space activities. He could probably supply better information.

But typically, 90 or 95 percent of the experiments that we want, we the government would want, would be man-tended. Jim, is that a good ballpark?

Mr. ROSE. Yes. I think that probably is a reasonable number.

The commercial world, it would depend entirely upon what phase of testing they were in. If they were still in what I called applied, the applied technology work, they would want a short time period. As they get into pilot plant development and ultimately into the first phase of commercial development, then the long duration is what they need.

And that is exactly what the ISF was developed to do, was to provide a manufacturing capability for commercial companies who had plants ready to go for the long distance.

Senator ROCKEFELLER. Let me go on, Dr. Fletcher, to another area. The Harvard Business School issued a report entitled "Progress toward space commercialization" in May of last year. In the report, the business school conducted a survey of 34 companies to determine industry concerns related to space commercialization.

These companies ranged from companies that were veterans of space flight and NASA procedures to those that were largely unfamiliar with NASA's activities and its various functional areas. In addition, the company size varied from start-ups to global giants.

One of the observations from this report was that: "A cost incurred by non-aerospace companies is the expense of learning to work with NASA and its suppliers. The task of plunging into a strange industry and relying on a large government agency is daunting to firms that do not benefit from a long history of working with NASA."

Does NASA make any special effort to assist first time, so to speak, firms which are interested in space commercialization, but that are not acquainted with the agency or its procedures?

Dr. FLETCHER. Yes, indeed, Mr. Chairman. That is perhaps one of Mr. Rose's main missions, is to reach out to those non-aerospace companies. And he has done an outstanding job so far in doing that.

But we have, among other things, set up these commercial centers for space development—there are a number of them throughout the country—which are joint centers involving universities and several companies, each one. And many of these companies are commercial companies.

But Jim's activities go beyond that, and maybe you could give a rough cut at some of the things we do.

Senator ROCKEFELLER. Jim, before you do that, let me go on to this next, because I think you will want to respond to this, too.

Again in this report, some of the companies felt that NASA was failing in its marketing communications efforts. And again from the report:

"Complaints were also registered against NASA's print and bill marketing materials for being too general and not answering the specific questions of sophisticated researchers. This and other complaints about NASA's commercialization policy would seem to indicate that NASA's approach may have become too standardized for companies that are seriously interested in space commercialization."

Dr. FLETCHER. Before Jim answers, I should say something, Mr. Chairman. Jim came on board about, what, eight months ago or six months ago, and he came from industry, and so we now have somebody that is going to set those policies to right.

But go ahead, Jim.

Mr. ROSE. I think there is—and I have been in the space commercialization field for twelve years, eleven of it on the industry side. And I have just come—

Senator ROCKEFELLER. From McDonnell-Douglas?

Mr. ROSE. Yes, and I guess the pioneering commercial venture going at one time. So I know the field reasonably well.

It always did worry me about how were we going to entice the small entrepreneurial type people into space, because I think that is where a lot of your good ideas come from. I know that to deal with any government agency, whether it be NASA or any other, it is arduous to go through the procedures unless you understand what you are doing.

And so one of the main areas of my office's responsibility is to work directly with those industrial firms, whether they be small or large, and especially on the small ones, to try to make sure they understand what it is they can expect.

And we are looking at ways—in fact, one of the biggest complaints that all of the aerospace world and non-aerospace companies wanting to do business with NASA has been the length of time it takes to negotiate agreements. Within a month after I arrived, the agency initiated several initiatives, one of them being a faster way of doing business, of getting in, getting agreements with the companies who want our help.

So we are doing what I think, the things that where I came from we knew needed to be done to invigorate the NASA program of working with the commercial sectors and getting them involved.

And I think you are going to see some results. In fact, your first question about the marketing our technology and our detail—we have already gotten last year started an outreach program, in which—and we have been having several workshops with companies.

The last one was held in Nashville, Tennessee, in November and we had 141 companies there, of which 50 of those companies had never been involved with anything to do with space before. So we think we are making progress.

Senator ROCKEFELLER. It seems like it. Thank you very much.

Now, one NASA program that seems to be valuable to industries which want to be more involved with space commercialization is the centers for commercial development of space, the CCDS. That program—with seven additional centers being added last year, NASA now has a total of 16 of them.

The CCDS program is unique in that it offers low cost, low risk entry points for companies wanting to get involved in space-oriented research. If all goes well with ground-based research, hopefully these companies will eventually become interested in actual space research aboard the Shuttle or the Space Station.

Is there an increase in the fiscal 1989 budget specifically for CCDS, and does NASA plan to continue to expand on this program?

Dr. FLETCHER. I can answer the second part of the question while Mr. Campbell is looking up the first part. Yes, it is planned to increase, and we do plan to add additional centers.

The actual number for the increase is a million dollars over last year.

Senator ROCKEFELLER. The CCDS budget for last year was what?

Mr. CAMPBELL. \$15 million.

Senator ROCKEFELLER. Okay.

The 15th point of the President's new space policy, entitled "Protecting U.S. critical technology," states: "The Administration is requesting that the Congress extend to NASA the authority it has given to the Department of Defense to protect from wholesale release under the Freedom of Information Act those critical national technologies and systems that are prohibited from export."

While protecting critical national technologies from export is important, this request would seem also to preclude NASA's technology transfer program to private industry, by withholding information from foreign as well as private industries.

How will the section of this policy work without excluding U.S. industry from NASA's technology utilization program?

Dr. FLETCHER. Mr. Chairman, that is an awfully good question and we have been wrestling with that. But I think the short answer is that when it is purely commercial, that is if they, like the ISF was originally, it is a commercial company's expertise that is being used, it is their dollars that are being used, we do not see how we can prevent the transfer of technology from one part of that company to another.

If it is research that is generated by the government, of course, that is a different matter and we do plan to protect that technology within the limits of that national space policy. But we right now do not see any way that we can prevent a private industry from either selling or using its technology that it develops on its own for the entire world. That is the nature of international business enterprise.

Somebody else may want to help me on that, but I think that is where we are coming from at the moment.

Senator ROCKEFELLER. In this budget, you have a significant increase for ELV's. However, according to the President's new space policy, NASA is now supposed to rely on private industry as much as possible for launch services. Since the new ELV launches are being launched through NASA contracts, what role and to what degree will NASA play concerning oversight or supervision of these launches?

Dr. FLETCHER. Well, as you mentioned, Mr. Chairman, we will be purchasing launch services from the commercial sector in the future. And we of course, in purchasing those services, we will have to specify the degree of reliability and so forth that we require.

There will be some oversight of the services, particularly those involving NASA critical payloads. We are not going to allow our expensive payloads to be launched on a fly by night ELV.

But so far, all of the expendable launch, commercial expendable launch vehicle companies, are companies that have been doing business with NASA and so they know what our requirements are. And so I would say a minimum of oversight will be required for them.

Now, for the newcomers on the scene, which are usually the companies with smaller payloads, we will have to deal with those one at a time as they appear.

Senator ROCKEFELLER. There was a February article in "Forbes Magazine" that was called "Is it time to bust up NASA?" And it claims that NASA should take the initiative of leasing out some of its launch pads to private industry. It states:

"And there are many launch pads for conventional rockets that are reverting to sand and dune grass, which private sector companies like Martin Marietta, General Dynamics, or McDonnell Douglas, or one of the emerging start-ups like American Rocket Company could in fact use if NASA would tolerate it."

You may either respond now or respond later in written form: How many launch pads have been built at Kennedy Space Center? How many are still being used by NASA? How many launch pads are still in operating condition for the launch of ELV's, or at least could be refurbished to allow launches by ELV's?

Dr. FLETCHER. Mr. Chairman, we will supply those details for the record.

[The following information was subsequently received for the record:]

The John F. Kennedy Space Center has two launch pads, Complex 39 A/B, and both are used for Shuttle. NASA ELV launch pads on the Cape Canaveral Air Force Station (CCAFS) that are still used are Complex 36 A/B for Atlas/Centaur and Complex 17 A/B for Delta. There are additional ELV pads owned and operated by the Air Force on CCAFS. NASA is currently responsible for Complex 36 A/B. NASA is presently in the process of returning responsibility of Complex 17 back to the Air Force.

Dr. FLETCHER. Let me address that article. First of all, we have made all of our launch facilities open to commercial launch companies. In fact, facilities already at Wallop's Center have been made available for one private company. We are negotiating with another one down at the Cape for use of a different launch facility.

The particular facilities that are referred to at the Cape that are for larger launch vehicles and for larger payloads, nobody really has come forward and asked for those. I am sure if such a company existed—and so far, as I mentioned, they are smaller payload companies, smaller rockets that are involved.

If somebody would come forward, we would make those available. But let me just say, I had difficulty understanding that Forbes article. I read it several times and there was a lot of fuzziness in what they were recommending.

And I have suggested to the magazine that they re-examine the quality of the work that they put out. I am a subscriber to Forbes Magazine, but I am seriously questioning whether, if they put out many more articles like that, whether I will continue to be.

Mr. MYERS. Mr. Chairman, we do have specific agreements with McDonnell-Douglas, General Dynamics, and Martin Marietta at the Cape for support services for the use of the facilities down there.

Senator ROCKEFELLER. All right.

Another question. In 1987 NASA began studies on a heavy lift vehicle called the Shuttle C. The Shuttle C program relies heavily on Shuttle technology and it will be used to lift sections of the Space Station into orbit. The Shuttle C is essentially an unmanned expendable launch vehicle.

The Shuttle C program is scheduled to run for a period of ten years, beginning with its first launch in 1993.

What, if we know, is the total projected cost of the Shuttle C program?

Dr. FLETCHER. Mr. Chairman, we spent a lot of time estimating the cost, but until we get contractors on board that are really addressing the cost question, any cost estimates that we give today would be preliminary. But I will be glad to do so, to give you my guess.

But let me say that the funding for the Shuttle C so far has been for how it would be used for NASA programs, particularly as an interim advanced launch system. And you are quite right, there are a lot of uses that the Shuttle C could be put to, including launching of critical payloads to the planets and so forth, implementing the Sally Ride missions.

There is a lot of versions of the Shuttle C. But the version that is the least expensive, that would cause the least impact on NASA, would be a version in which we would simply take off the orbiter itself and replace it by a small cargo bay with two Space Shuttle main engines attached to it.

That would be capable of lifting something close to 100,000 pounds, 120,000 pounds to orbit, which is more than double what the Shuttle could do. And that could have a lot of uses downstream for new projects, but also it would help in resupplying the Space Station.

The approximate cost of that version of the Shuttle C would be on the order of \$1 to \$1.5 billion, which is a bargain in my opinion. And it is something that ought to be done. But we cannot do everything, as you pointed out at the beginning of this afternoon's session.

This is one thing we would very much like to do if we had the money.

Senator ROCKEFELLER. Is the Department of Defense funding any part at this time of the Shuttle C?

Dr. FLETCHER. No, the Shuttle C is considered to be part of the advanced launch system program, and it would be an interim advanced launch system. As you may recall, the advanced launch system is a joint program between the Defense Department and NASA for a very advanced launch system to be available about the end of the 1990's for a lot of purposes, some of which are ours and some of which are the Defense Department's.

We—the studies that we are conducting now are looking at the Shuttle C as an interim advanced launch system, and it could do a lot of the things that the ALS could do, but it would be more costly.

And so the purpose of the real advanced launch system is to reduce the cost. Now, those studies are all in the fiscal 1988 budget, as I mentioned. We wanted it in the fiscal 1989 budget, but we just did not have enough money for everything and so it was one of the programs that was dropped in the fiscal 1989 budget.

Senator ROCKEFELLER. Dr. Fletcher, I unfortunately am required to be at another place at this point, and so I am going to declare a three or four minute recess. Chairman Riegle is on his way, and I have to be on my way. And so I thank you for your courtesy, sir, and I look forward to working with you.

Thank you very much.

[Recess.]

Senator Riegle [presiding]. The committee will resume.

Let me thank you for your patience. Today is one of those days, like most days around here, where there are so many things going on at once that it is tough to attend to them all.

Is Mr. Ballhaus here at the moment? If he would come up and join us, at this point we would like to move into the aeronautics space research and technology area.

Mr. Ballhaus, let me welcome you to your new position. You come with high praise and marks for the work that you did at Ames, and I am sure that you will have a similar impact upon NASA headquarters.

Now, the fiscal year 1989 NASA budget request for aeronautics R&T and space R&T represents an increase of nearly 46 percent when compared to the fiscal year 1988 baseline. The bulk of this increase is for the new space research and technology initiative.

Based on the level of these increases, is it fair to say that restoring NASA's technology base is a high agency priority?

Dr. BALLHAUS. Yes, Senator, that is correct. A number of outside advisory groups have recommended that and we concur with that.

Senator RIEGLE. I am interested in high speed transport technology, which appears to be the next breakthrough in transportation technology. Studies clearly indicate that the manufacture of a large high speed transport in the range of 300 passengers flying at Mach 3 or higher would offer some great commercial possibilities.

So let me ask you, where does the United States stand today in the development of high speed transport technologies?

Dr. BALLHAUS. Well, Senator, as you may know, we had studies going on in the early 1980's. We had the variable cycle engine program and the supersonic cruise program, and those were terminated in favor of other activities.

More recently, we have done some studies with industry, with Boeing and with McDonnell-Douglas, and those studies have not been completed yet, but preliminary indications are that there is a potential market in the 300 passenger area for about a 600—I am sorry, a 6,000 nautical mile transit.

It looks like there is a market, and we are working some of the technologies, both in the aerospace plane program and in our base program.

Senator RIEGLE. We are going to be having a workshop in May to take a look at this, but let me ask you, who are the other competitors in the world that are moving down this road and where do they stand?

Dr. BALLHAUS. Well, certainly the Soviets and also the Europeans have operational supersonic transports, and we do not. So you would have to say that they are in the lead and we are in the process right now of coming up on the learning curve and developing the technology that could be incorporated in a high speed civil transport.

But much more remains to be done.

Senator RIEGLE. How long would it take us to design and develop and build a high speed transport aircraft?

Dr. BALLHAUS. Just a rough, back of the envelope estimate, I would say it would probably take us on the order of six years to develop the long lead technologies, and once we accomplish that, probably on the order of six to seven years to develop an aircraft, to get it certified and into operations.

Senator RIEGLE. There has traditionally been a beneficial relationship between the NASA aeronautics program and our commercial aircraft industry, contributing to a positive trade balance of about \$17 billion in 1987. We have not had too many sections like that, and so we are very sensitive about protecting and enhancing that one.

However, during the last decade the U.S. share of the international transport aircraft market has declined from an average of 85 percent for the seventies to about 65 percent in 1987.

Can you tell us what NASA is doing in its aeronautics program to transfer technology faster to the commercial aircraft and engine companies to try to maintain our competitive lead?

Dr. BALLHAUS. Well, Senator, you very rightly point out that the aeronautics budget is one of the few wealth-producing areas of the Federal budget. It is an extremely important area. We have augmented the program in going from 1988 to 1989.

The difficulty in technology transfer is a real one. Coming here as a center director, I have been involved in that process for a number of years. We use a number of innovative techniques to try to get technology out of the laboratory as rapidly as we can and into the hands of the potential product developers in this country.

One way we do that is by inviting industry participation in joint activities. And for example, we had a couple of very successful activities that are in the process right now of returning revenues, not only to the industry but also to the Treasury.

Dr. Fletcher received a check the other night I think for about \$3 million.

Dr. FLETCHER. It was \$3.6 million.

Dr. BALLHAUS. That is an investment the government made in conjunction with industry, and now the government is reaping the benefits as well as the industry. And in addition to that, we have already saved \$360 million in fuel costs, which is substantial.

The joint programs with industry I think are one of the best ways to transfer technology. In addition to that, we invite industry research associates to visit our laboratories for extended periods and pick up the technology and then take that back to their companies and train their own people in the use of that technology.

Clearly, though, much more needs to be done in the future. We need to work that very aggressively.

Senator RIEGLE. In fiscal 1988, NASA's requested funding for the Pathfinder program. As a result of the findings of the Paine Commission that noted serious deficiencies in NASA's technology base, OMB rejected Pathfinder, but agreed to fund the civilian space technology initiative, another Paine initiative that is related to low earth orbit projects.

And now Pathfinder is being proposed as a new start in 1989.

What is the total estimated cost of the Pathfinder program?

Dr. BALLHAUS. Pathfinder is an ongoing program and so we do not see a point at which it will come down. It is going to lead us into future space missions to the moon and to Mars and so forth.

But over the next five year period, we have costed it out at about \$840 million. It starts in fiscal year 1989 at \$100 million and then goes up to about the \$200 million level as it builds up in increments.

Senator RIEGLE. How much of the \$100 million requested in fiscal year 1989 is for ongoing activities?

Dr. BALLHAUS. That is difficult to sort out, Mr. Chairman. I would estimate about \$40 million is for increases in various ongoing activities and the rest is basically new.

Senator RIEGLE. My understanding is that about \$15 million is transferred to the office of space exploration and \$30 million, as you say, is for an ongoing program, and about \$55 million is for new technology. Would that be about right?

Dr. BALLHAUS. That is correct.

Senator RIEGLE. Is that enough?

If Dr. Fletcher just picked up a check for \$30 million, I thought I might help him spend it here.

Dr. FLETCHER. Dr. Ballhaus's predecessor, Ray Colladay, asked for a substantial amount larger than that. But during this era of tight fiscal constraints, all we can see seem to fit in was \$100 million. That is why it gradually builds up to \$200 million by about the fourth or fifth year, and that is about the level it ought to be.

Dr. BALLHAUS. That is what I would have said, sir.

Senator RIEGLE. I sort of thought so.

Is the goal of the Pathfinder program formulation of a technology base that permits the selection of a bold new initiative in the fiscal year 1991-92 time frame?

Dr. BALLHAUS. That is correct.

Senator RIEGLE. What are the leading mission candidates?

Dr. BALLHAUS. Well, right now, Senator, the leading mission candidates are the ones studied in the Sally Ride initiatives, and that includes lunar base, an outpost on Mars, robotic exploration of the solar

system, and return to planet Earth, or a global investigation and examination of the Earth.

Senator RIEGLE. Now, last year NASA initiated a new university space engineering research program and the response has truly been incredible, as most people here know: 150 proposals for eight awards that will be made in April of this year.

What level of funding has been included in the fiscal year 1989 budget for this new program, and how does that compare with 1988?

Dr. BALLHAUS. Senator, in 1988 we have earmarked \$4 million, and that is so we can begin the awards. And as you point out, April is the date that we are shooting for or the month that we are shooting for to begin those awards.

In fiscal year 1989, we have earmarked about \$14.2 million to support that activity, and that would allow us to support the eight universities that we select this year and then select an additional eight or more next year.

Senator RIEGLE. I feel very strongly about that, and I am glad to hear that answer.

Do you have any idea what the average value and duration of an award might be?

Dr. BALLHAUS. Well, this year we will earmark about 500K to each of the universities, and then next year we would hope to build that up to on the order of \$1 to \$2 million per university.

Senator RIEGLE. Now, is one of the goals of this program to broaden the base of the university that is involved in space engineering?

Dr. BALLHAUS. That is correct.

Senator RIEGLE. Am I correct, 13 percent of the aerospace budget for 1989 will go to the university community?

Dr. BALLHAUS. That is correct.

Senator RIEGLE. Regarding, the wind tunnel revitalization program submitted recently to the Congress by NASA, the committee feels that this is a much needed investment in the restoration of the quality and capability of our aeronautics wind tunnels.

The 19 wind tunnels included in this five year revitalization program average about 30 years of age, and have been a critical component in the preeminence of the nation's commercial and military aircraft. My question is whether NASA's priority for this program high enough in the construction of facilities program planned for the next five years to ensure completion of the identified group of wind tunnels?

Dr. BALLHAUS. Senator, I would certainly hope so. Coming here as a center director, I think that is extremely important. But I think I should defer to the Administrator on that point.

Dr. FLETCHER. Well, Mr. Chairman, we have taken the bull by the horns in terms of modernization of wind tunnels, and a large fraction of the increase in construction of facilities, the CFS in 1989, is for that purpose. I believe something like \$64 million is for wind tunnel modernization.

We expect that to be a five year program, and we have given a run-out of that program, and we would like to have it appropriated for the full five years. But we did not ask for that.

But it really is only the start, and hopefully by the time that five years is up, if it is fully funded, we will have up to eight modern wind tunnels.

Senator RIEGLE. What is the condition of the 31 wind tunnels that are not included in this program?

Dr. FLETCHER. You have got me, Mr. Chairman.

Dr. BALLHAUS. I can comment on that.

Dr. FLETCHER. If Dr. Ballhaus can answer, more power to him.

Dr. BALLHAUS. I cannot comment on the status of each one of them, but I can say that we did do a fairly thorough study of our wind tunnel resources within the agency, and we had an outside committee made up primarily of people from the industry and other government agencies review each of the wind tunnels and prioritize them.

And we looked at what made sense to do in view of the tight budget constraints this year, and we came up with what we thought was the highest priority items to be refurbished.

Senator RIEGLE. We are going to give you some other questions to answer for the record. But we thank you for your testimony.

Senator RIEGLE. Let me excuse you and invite Mr. Rodney to join us at the table.

The proposed 1989 budget request includes an increase of \$8 million, which would take us from \$14 million in 1988 to \$22 million in 1989, for safety, reliability, and quality assurance. Can you explain to us what this increase is for and why is the bulk of the increase and the bulk of the NASA budget in this area allocated to headquarters?

Mr. RODNEY. Well, first of all, the headquarters budget which I administer, approximately 50 percent of that does go out to the centers, primarily for technology efforts, doing NDE development, and certain reliability enhancements and electronic piece parts and batteries and things of this nature.

So only 50 percent of it is spent in the headquarters directly. The majority of the increase is directed at increasing this technology effort and in giving us more assets to do independent technical assessment and risk management.

Senator RIEGLE. What presence does the office have at the facilities of the space program's major hardware manufacturers?

Mr. RODNEY. Well, we have—each of the center SR&Q offices have co-located people at each of our major contractors. However, the bulk of our effort is done by contract by the Air Force resident offices and the Navy resident office, or DCAS.

And however, we also have very close reviews by my office. I go around to each of the major contractors at least every other month, and I have a monthly review of their activities.

Senator RIEGLE. What do we have at the Space Shuttle assembly point at the Kennedy Space Center?

Mr. RODNEY. At Kennedy, of course, the basic operation is done by the resident contractor, who has their own quality force. And that is supervised, in this case by a NASA operation, civil service, NASA civil service SR&Q operation.

Senator RIEGLE. Can you tell us what the role of the office has been in getting more and more non-destructive evaluation techniques incorporated into the Space Shuttle program?

Mr. RODNEY. Yes. We have been developing new techniques. As I said, we have a lot of technology development going on. We have been instrumental in getting a new ultrasonic technique available for work on the SRM.

We have also developed a new electronic—well, it is an ultrasonic system that replaces the conventional torque wrench which is being used both on the SRM and on the SSME. We are doing some advanced work in thermal mapping to help us again in inspecting the SRM.

And we have also developed a new technique for determining when a surface is clean, which is a major advance.

Senator RIEGLE. Let me ask you this. Do you support the construction of a new non-destructive evaluation test facility at KSC for solid rocket motors, or are you comfortable with the fact that the last inspections are at the Morton-Thiokol facility prior to shipment?

Mr. RODNEY. Well, we have been supporting increased inspection at the Cape. However, the statement that the last inspections are at Morton-Thiokol is not correct. We do a significant number of additional inspections at the Cape, both before we assemble the individual case segments and after they are assembled.

So there are numerous inspections that go on throughout that entire process.

Senator RIEGLE. We are going to at a later time review with you the recently announced NASA aerospace safety panel report, so we can both look forward to that.

Thank you.

Senator Adams, I have got a couple of questions to ask here. But if there was anything that you wanted to pose at this time, I would be happy to have you do that. Or if you wanted to make any comments, we would be delighted to have you do so now. Or would you prefer to wait a bit?

Senator ADAMS. Thank you, Mr. Chairman. I will.

I apologize for not being here the rest of the day, but we have the INF hearings and Senator Nunn is testifying at this moment, and that was why I have had to come in and leave. But I would like to ask a couple of questions if I could, with your indulgence.

Senator RIEGLE. Please do.

Senator ADAMS. Dr. Fletcher, good afternoon.

I have been following these hearings as we have been doing the other hearings during the course of the day, and it is my understanding that you testified to the committee this morning that you would go ahead with the Space Station program even if you took another appropriations reduction like you took last year.

I would like to ask you once again what you see as a minimum level of funding necessary to move forward with this program at a reasonable pace. I support it and I am going to ask you in a minute about heavy lift vehicles. But I just want to know the answer to that question first.

Dr. FLETCHER. Senator Adams, I have not really decided anything with regard to what would happen if we took a cut comparable to the one we took last year. But I would guess that if we took a cut down to the level of what we had last year, which is about, well, 325 plus some left-over money from the year before and so forth, something on the order of \$500 million, I think that is coasting and it would be a waste of government money to continue on at that level.

And so I think we have to be supported at substantially the level asked for, which is close to a billion dollars. I think the total number is \$950 million, plus some more for facilities.

So I do not think we can suffer very much of a cut from that number and still survive.

Senator ADAMS. Is the President willing to throw his support behind this program to attract the support necessary to move it ahead?

Dr. FLETCHER. I cannot speak for the President.

Senator ADAMS. Well, I assume that since you are here as at least a representative of him, that you would have some knowledge on that subject.

Dr. FLETCHER. That is correct. He has assured me that he will speak up at the appropriate time in favor of the space—the NASA budget, along with the other priorities, which are science and education, as you know. That is his major thrust this year, is education and science and space.

And I am quite sure that he will come forward on those questions.

Senator ADAMS. It is my understanding also—and I am very interested in this because we have a large technological base of scientists at the Hanford facility in the state of Washington which have been involved in nuclear work which is being terminated or phased down.

It is my understanding that you do have a Pathfinder program that you are proposing. I am not asking for the amounts, but if you could give me some kind of an idea of what this program would look like and confirm with me that it is a new start program, in other words for new scientific endeavors that tie to the NASA program?

Dr. FLETCHER. Senator Adams, the Pathfinder program, which is part of the President's new national space policy, has in it for fiscal 1989 about \$100 million. Part of that—it goes for a wide variety of things. I think there are eleven different classes of technology that are being pursued.

Perhaps one of the ones that you might be most interested in is the SP-100 space nuclear power supply, which is a joint program with the Defense Department and the Department of Energy, which will produce a nuclear power supply for space use, which has a variety of purposes, particularly if we go deep into the solar system with our unmanned probes, which is part of the Sally Ride initiatives, or if we decide to produce or build a base on the moon.

As you know, the moon only shows itself to the sun every 28 days, and so that is a long time to be storing solar energy. And so the chances are, if we go back to the moon on a more permanent basis, it will require a nuclear power supply.

Senator ADAMS. We actually had a program like that in the sixties, as I remember.

Dr. FLETCHER. You are quite right, Senator Adams, and I was part of that program. And it was a shame that it was terminated, but we were shortsighted then and I hope we are not shortsighted now.

Senator ADAMS. Well, I wanted to raise it with you. I hope the \$100 million figure is not just a PR figure, because this has both peaceful and other uses, but I am particularly interested in the peaceful uses of it. And the ability to generate in space was something that I regretted also that we dropped in the sixties at that time. And I just wanted to check on that.

My final question—and Mr. Chairman, I do appreciate your allowing me to come in on this kind of a basis—is that I just want to state my concern, Dr. Fletcher, to you and the other members of NASA that we have pursued the Shuttle program at great expense, at considerable danger, and with the type of results that—and I am speaking only for this Senator—that something that I felt was predictable.

I do not think it is a transportation vehicle. I think it is an experimental vehicle, and it can be used in conjunction with Space Station to do work on it, to place personnel in space.

But I just want to state that I think it is absolutely essential that you devote you time and energies to—new expendable launch vehicles; heavy lift power, in order to move items into space at less cost, with less risk.

And if it comes to an alternative between building a new Shuttle or stopping the Space Station, for God's sake build the Space Station and go with heavy lift vehicles. They are simply constructed. We have had a lot of experience with them.

And I am appalled at the fact that we allowed our entire inventory to disappear. I have stated this before, Mr. Chairman. I have not asked it in the form of a question. I did not make an opening statement. I have not tried to interfere with the flow of your hearings, but I wanted to mention it again to you and to the NASA officials, because I feel very deeply about it.

And you and I were both involved in the space program in the House of Representatives during the sixties and the seventies and we saw great success from it. But I think it takes vision and I think it takes basics with the vision, vision to have a Space Station and to go further into space, with practicality, to do it with the vehicles that are available, and that do not allow the Soviet Union or others to simply take space away from us.

And with those remarks, Mr. Chairman, I thank you for your indulgence. And you and I will have an opportunity to talk about it at greater length. But I do not want these hearings to go by without my publicly stating on the record to you my concerns in that area.

Senator RIEGLE. Very good. Thank you, Senator Adams.

Mr. Aller, can we ask you to join us at the table now.

The 1989 NASA budget request includes an increase of approximately \$150 million for space and ground networks, and that is an 18 percent increase over the 1988 baseline. Is the bulk of this increase the cost associated with the replacement of the TDRSS satellite lost during the Challenger accident and the construction of a second TDRSS ground terminal at White Sands?

And what are the exact increases for these two programs?

Mr. ALLER. Of the increase, Senator Riegle, approximately two thirds are the items that you have indicated. The spacecraft that we lost on the Challenger, we started two years ago to replace it. It is an ongoing program today, and \$43 million of that increase is related to that replacement spacecraft in the 1989 budget.

Of the second ground terminal, which is the only single point failure we have in the entire data system associated with low earth orbiting vehicles, the increase is \$62 million in 1989.

Senator RIEGLE. Are either of these programs time critical?

Mr. ALLER. Yes, sir, they are. I would like to explain that what we are talking about is the infrastructure for being able to operate in space.

We have, in my view, two major elements to be able to conduct space operations, one of which we spent a lot of time talking about today, which is the launch capability, the capability to access space.

The other element that has to be there is the data system to retrieve information from space. Several years ago we converted to the Space Network, the so-called TDRS network, which consists of spacecraft in orbit. This requires us to maintain those spacecraft in orbit and assure those spacecraft will be there when we need them and assure that the ground stations that operate with those space stations, those spacecraft, are operable through that period.

So the problems we have had with that system getting it on line necessitate the need for the replacement spacecraft and the second ground terminal.

Senator RIEGLE. Let us, the TDRS I is in orbit, but its performance has degraded.

What is its current status, and what are your plans for this spacecraft?

Mr. ALLER. TDRS I has indeed had some problems, and it has been in orbit roughly five years now, Senator. It has suffered several failures. The first was getting into orbit where we lost half of our thrusters attaining orbit in 1983. We have had failures in what we call the forward link, our ability to transmit to other satellites in orbit in both frequency bands in which we operate. We have had a failure in our pointing system of one of the antennas, and we have had some gyro failures.

However, the vehicle was built with redundancy in it, and today it is operating reasonably well, although it is in some areas rather precarious in its operation.

Our plans for that satellite are to keep it in orbit as we launch the next two. We will then locate that as a spare and will replace it as a spare in 1990. So its active role is through 1990 as we presently view it.

Senator RIEGLE. What is the minimum number of fully operational TDRS satellites that are required for space shuttle operations?

Mr. ALLER. The number is three, sir. We have one in the east, one in the west, and one as an active spare.

Senator RIEGLE. And how about for Space Station operations?

Mr. ALLER. For Space Station operations, we look at the mid-nineties and look at the mission model that we anticipate during that period, and we plan to increase the configuration in orbit or the number of satellites in orbit to four in that time period.

Senator RIEGLE. Let me ask you about the Space Operations Task Force.

What is the current status of the task force, and what are the operational challenges that are presented by an international complex like the space station?

Mr. ALLER. Well, I think the—let me talk to the first part of that question.

A year ago Dr. Fletcher actually did two things. He said we are going to accept the role of operations and future operations in NASA, and formulated the Office of Space Operations, which I head. However, the principal task he gave us at that time was to look at what operations should be in the longer term, and I formed a task force just about a year ago that turned in a report late last year. That report, which deals with the long range structure, is being considered by NASA management, by myself, Dr. Fletcher and Mr. Myers, as well as an input from General Phillips who reviewed the same question.

The assets that we have to operate in the time period of the Space Station are many, and there is no question in my mind and no question in anybody's mind that knows anything about space operations that when we are looking at that activity which will involve a launch vehicle, shuttle, the TDRSS spacecraft, other spacecraft as well as the space station, it is a very large operation, demanding a large amount of attention on the part of NASA.

Senator RIEGLE. We are going to have some additional questions for you for the record, and we will, I think, from other colleagues in many of the sections that we have covered today.

I want to thank all of you for being here. I know it is difficult to have the day interrupted such as we have had it today, but I appreciate the effort by all, and I want you, Dr. Fletcher, and your colleagues to again take back the message to all of those people that are working with you at NASA, all the way through the operation, that we appreciate all the hard work.

We know there is tremendous pressure associated with getting ready for that August launch, and we appreciate all that hard work, and the fact that everybody's contribution is crucial to the success of the whole effort is something that we recognize, and that effort is deeply appreciated by all.

Dr. FLETCHER. Mr. Chairman, let me just thank you for your courtesy in dealing with our responses, but let me also say that we assume that you are working equally hard for NASA, trying to get our budget

passed by Congress, because that means a lot to the people at NASA as well as the rest of the nation.

Senator RIEGLE. Well, we are, and it is not an easy task, I might say. We are in a real budget squeeze, and I think we did pretty well last year under all the circumstances, and we are going to do the best we can.

The committee stands in recess.

[Whereupon, at 3:15 p.m., the committee recessed subject to the call of the Chair.]

[The following information was subsequently received for the record:]

STATEMENT OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

INTRODUCTION

The American Institute of Aeronautics and Astronautics (AIAA) is a non-profit professional society dedicated to advancing the art, science, and technology of aeronautics and astronautics and to promoting the professionalism of those engaged in these pursuits. We have a membership of over 40,000 drawn from all levels of American industry, academia, private research organizations and government, as well as from numerous nations abroad.

The members of AIAA are deeply concerned about this nation's continuing budget and trade deficit. Federal investments in civil aerospace, however, make a vital contribution to future economic competitiveness, international leadership, national security, creation of productive jobs, and a renewal of national pride. As in the past, a vigorous space program will more than pay for itself and assure American leadership in exploring and exploiting the space frontier for the benefit of all.

In this light, the Administration's FY 89 budget proposal for NASA is not a lavish one; indeed, it is barely adequate to maintain current capabilities and to lay the groundwork for essential future developments. Should overall budget pressures force significant reductions in that budget, critical elements of the U.S. civil space program will suffer, perhaps irreparably.

The AIAA strongly suggests that in this Subcommittee's review of the NASA FY 89 budget proposal you keep in mind these overriding concerns:

NASA urgently needs to improve and enlarge its technology base, which is the foundation of its future capabilities. Support for renewing that base must not be allowed to decay, even though much of its payoff will come in the future.

Completion of current programs in both science and infrastructure development must take precedence over the introduction of new programs. The costs of program delays and stretch-outs, as measured in capability, motivation, accomplishment, and most particularly dollars, must be avoided.

The main cost drivers in space activities are technology development and operations. Any reductions in nonrecurring development costs early in a program are to be avoided if they result in substantially higher recurring (operational) costs later. The Shuttle program is a prime example.

In the light of these overriding concerns, we offer our view of the Administration's FY 89 budget proposal for NASA.

SPACE TRANSPORTATION

A sound and cost-effective Space Transportation System (STS) capability continues to be needed for both civil and military programs. We strongly support the guidelines enunciated in the President's 1988 space policy that prescribe a mix of vehicles consisting of the STS, expendable launch vehicles (ELVs), and in-space transportation systems.

As the STS returns to flight status and begins its gradual flight rate increase, funding for extending the Orbiter's time in space, for an additional set of structural spares, and for advanced solid rocket motor development makes good sense. We strongly sup-

port the proposed increase in space research and technology for activities aimed at reducing the costs of transporting payloads, both in orbit and from the Earth's surface into space. The Advanced Launch System (ALS) development effort by the DOD and NASA should be effective in avoiding duplication of programs, ensuring the most efficient use of government resources.

Experience with the STS has shown that efficient in-orbit transportation is also essential to low-cost space operations. The AIAA therefore supports the goal of a 1993 first flight of the orbital maneuvering vehicle (OMV). This system will extend the Shuttle's capabilities and play an important role in space station deployment and operations. We also see the need for a new, fully reusable high-energy upper stage for future Earth and planetary exploration.

SPACE STATION

In keeping with our above-stated concerns, we believe current space station funding practices should be changed. Multi-year budgeting would allow the cost savings associated with long-term commitments and planning. The current practice of withholding funding from a program within a budget year is especially devastating to a development program. Rather than cutting funds and slowing down the program, the Congress should direct NASA to get the space station on line at the earliest practical date.

Because the space station will be in operation for decades, the cost of future operations must be determined at an early stage. The NASA Space Station Operations Task Force's recommendations aimed at reducing the costs of operations and encouraging industrial commercialization participation should be implemented expeditiously. Present and planned ELV systems must be incorporated into space station deployment and operations planning, and the current strong emphasis on automation and robotics R&D should continue.

SPACE SCIENCE

The U.S. space science program is a national resource. We applaud Dr. Lennard Fisk's leadership in creating a coherent, forward-looking program for NASA's Office of Space Science and Applications, as reflected in the FY 89 budget proposal.

The proposed new start for the Advanced X-Ray Astrophysical Facility (AXAF) is a cornerstone of NASA's space science program. AXAF has been the highest priority mission for many years; its adoption will reassert this nation's preeminence in the field it pioneered.

It has been eleven years since the U.S. launched a new major planetary exploration spacecraft. Foremost in this area is the Mars Observer program; its funding should certainly continue. We also fully support NASA's aggressive plans, beginning with Magellan and Galileo, for close observation of several planets.

In keeping with the overriding concerns cited above, AIAA strongly supports the Hubble Space Telescope, Gamma Ray Observatory, Upper Atmosphere Research Satellite, ocean Topography Experiment, and Global Geospace Science missions. We commend NASA's funding of instrumentation development for the Earth Observation System, a program that will provide the best and most comprehensive analytical view ever of Earth as a total system.

The Explorer and suborbital programs have been the proving grounds for innovative ideas in physics and technology. They have provided most of our information about the ionosphere and magnetosphere and have served to attract and keep students in space science research. The proposed funding increase for the Explorers program, particularly the Scout-class payloads, has been long-awaited. We recommend that funding for this program be provided for a three-year period to provide stability.

We urge that payload and instrument development funding for the High Resolution Solar Observatory (HRSO) be made a high priority. Breakthroughs in understanding of the magneto-hydrodynamic energy release mechanism responsible for solar phenomena can come only from this program.

Expanding human exploration of the solar system will require a more complete understanding of how living systems react to the stresses of space flight. We commend NASA for proposing an excellent life sciences program, one that focuses on the centrifuge and long-duration crew operations. These and other space-station programs, along with elements of the Pathfinder initiative, are essential to the planning of human

exploration of the Moon and Mars. We also urge continuation of the joint U.S./ Soviet program for analyzing long duration space flight.

SPACE TECHNOLOGY

Technology advancement heads our list of overriding concerns. It is therefore gratifying to see it strongly supported by the Presidential policy statement and by substantial funding in the NASA budget. Support for the Civil Space Technology Initiative (CSTI), and especially the New Pathfinder program, promise immense returns in both civil and commercial space sectors.

But the FY 89 NASA budget request is only the beginning of what must become a long-term commitment to space technology development. Too often budgetary pressures have resulted in substantial cuts to the technology base, necessitating catch-up programs later. This is very inefficient, and we urge that you support these critical programs and maintain them in the future.

SPACE COMMUNICATIONS

To regain U.S. leadership, NASA has in recent years focused its space communications R&D effort on the Advanced Communications Technology Satellite (ACTS) program. Although the FY 89 budget request eliminates ACTS funding, it is urgent that the program continue. While many incremental communications capabilities are being developed by the private sector, the critical high-risk technologies represented in ACTS, such as scanning beams and on-orbit switching and digital processing, are not yet suitable for commercial use. It is therefore appropriate for NASA to support this R&D until U. S. industry can bring these technologies into the market-place.

COMMERCIAL PROGRAMS

The AIAA applauds the Administration's strong commitment to fostering the growth of private-sector involvement in space. We endorse NASA's efforts to develop private-sector links via the Centers for Commercial Development of Space and the creation of multi-user hardware. NASA should facilitate this initiative by providing industry with technical guidance and expertise during the planning phase as well as space transportation, orbital R&D facilities, and ground test and training facilities. Because the government should not fund commercial activities, a plan is needed for cost sharing and, where appropriate, cost reimbursement to NASA. If NASA takes the lead in developing facilities for industry research leading toward space commercialization, the initial investment should be recoverable as the facilities are used by industry. It is reasonable to expect industry to fund product R&D and a fair share of facilities, costs, transportation, and other services. The risks, costs, and time required to bring commercially viable returns on space processing investments, however, are all far greater than those of ground-based investment alternatives. It is not reasonable to expect industry to do it alone.

It is also entirely appropriate for the government to undertake the development of space processing facilities whose products may be useful to its programs. NASA's aeronautics, communications and weather satellite programs are earlier examples. However, the lack of economical and dependable access to such facilities is causing scientific researchers and commercial enterprises to turn away from space processing.

To alleviate this critical need at the earliest possible time, the AIAA advocates expanded use of Spacelab and other Shuttle-borne facilities, and we commend NASA's decision to augment the Shuttle's on-orbit duration. We also support the early deployment and use of free-flying commercial space facilities for those experiments until the space station's more comprehensive facilities become available.

Thank you for this opportunity to present our views on the U.S. civil space program.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS THERETO
Space Station

The FY 1988 Space Station budget was cut from \$767 million to \$425 million in the CR. As a result of that reduction, OMB reduced NASA's FY 1989 budget request from \$1.872 billion to \$967 million.

Question 1: What impact did those two reductions have on the proposed space station's schedule and cost? When will the space station IOC occur? When will the space station be man-tended? Permanently manned?

Answer 1: The FY 1988 and FY 1989 budget reductions have caused a slip in the program of approximately one year. The impact of the stretchout on the total cost of the program is under review. However, the stretchout will require sustaining the base support of the program for a longer period. Exact estimates of how much the cost estimate will increase are currently being developed and will be available later this year.

First Element Launch of the Space Station will be in the first quarter of 1995. Following the results of the Early Man-tended Study requested by the House Subcommittee on HUD-Independent Agencies, man-tended capability will be realized on the fourth flight, scheduled to occur in the fourth quarter of 1995. Permanently manned capability will be accomplished after the tenth flight, in the fourth quarter of 1996. Assembly will be completed in the first quarter of 1998.

Question 2: What is the current budget run out for the space station program? How does this compare with last year's budget run out?

Answer 2: The current budget runout for the Space Station is the same as last year, plus inflation and the cost of the schedule stretchout. A new estimate incorporating these factors is being developed.

Question 3: Is it true that any reduction to the FY 1989 funding request would have a severe schedule/cost impact?

Answer 3: Yes, it is true that any reduction to the FY 1989 funding request will result in another slip in the program schedule, with a corresponding increase to the overall cost of the program. The budget requested represents what NASA needs to ramp up funding for the detailed design of the Space Station. Planned flight hardware design activities for the Work Packages requires the increase in budget that the FY 1989 budget request represents.

Question 4: Is it also true that any reduction to the proposed 3-year authorization and appropriation request -- \$1 billion in 1989, \$2.1 billion in 1990 and \$2.9 billion in 1991 -- would have a severe schedule/cost impact?

Answer 4: The program schedule described earlier is predicated on the availability of the funding in these fiscal years. Any significant reduction in any fiscal year would result in a schedule

slip and a total cost increase. The severity of this impact depends on the size of the reduction.

Question 5: What is the minimum level of funding required to sustain the space station program in FY 1989 if the Congress wanted to keep the program alive until the next President had a chance to review the program?

Answer 5: The Space Station has finally gotten off to a real start with the award of the hardware development contracts and an FY 88 funding that will allow contractor buildup and the initiation of meaningful hardware design and development activity. While the contractor and government teams could theoretically be kept intact at somewhat lower funding level, it is highly probable that any appreciable cut would take all the "momentum" out of the program and cause the team to dissipate.

Question 6: If the Congress cannot provide \$1 billion for the Space Station Program in FY 1989, should the program be terminated?

At what point does there cease to be any value to limping along at the current pace?

Answer 6: Terminating the Space Station Program after having invested well over one billion of Government resources in its Definition and Development would be a tremendous waste of resources. It would send a clear message to the American people and the world that the United States is foregoing its leadership position in Space exploration. Hence, terminating the program should be done only if the Congress does not intend to fund the program.

However, the program should not be forced to continue at consistently reduced funding levels -- increasing runout costs and delaying the operational readiness date. Such an approach implies that the United States is not intent on finishing what it started. Such an approach will cause the talented and skilled management and engineering teams currently working on Space Station to dissolve, leaving the program without the necessary talent to complete the job. It will also compromise our ability to develop the Space Station in a cost-effective manner.

Program funding requirements in 1989, and subsequent years, are real; if we are to meet our launch commitment in early 1995, and to do so within a restrictive budget environment, we must be able to adhere to a stable funding profile.

Question 7: Dr. Fletcher, is your basic space station message today that the current space station design cannot be reconfigured and that the current space station budget cannot be reduced -- that it's time to commit or time to stop?

Answer 7: The Space Station cannot be reconfigured any more and still meet the requirements for which it has been designed. The configuration has been studied very, very extensively in the past three years. It has been validated by panels and groups both within and outside of NASA. NASA has spent \$600 million dollars studying

it. It has been considerably pared down--to the point where there is little merit in reducing anymore hardware. Furthermore, other development cost savings are inadvisable because they would be less than the corresponding increase in life cycle costs. We must be willing to pay the up front costs of development if we are to avoid paying much higher logistics costs once the Station becomes operational.

Space Station Personnel Levels

On December 12, NASA issued a stop hiring order for the space station program support contract. NASA also has implemented a hiring freeze because of reductions to the NASA FY 1988 budget in the Continuing Resolution. Furthermore, no request is included in the FY 1989 bill for space station civil service personnel.

Question 8: In light of this situation, does NASA have the ability to manage and implement the space station program?

Answer 8: NASA is still able to conduct the program management activities minimally necessary to meet the year delay schedule. A build-up in PSC will be possible if the FY 1989 funding is approved. We are continuing to provide for some limited civil service growth in the Space Station program by reassignment of existing personnel.

Question 9: Will NASA be able to add any additional civil service or program support contractor personnel to the program in FY 1988? in FY 1989?

Answer 9: Most contractor and civil service hiring is being capped, although some PSC build up will be possible if the FY 1989 funding is approved. The only additions in numbers for FY 1988 will come from transfers to the program from other NASA programs.

Space Station Funding Constraints

The space station program was funded at \$425 million in the CR, compared to the President's request of \$767 million. The program was then reduced by \$33 million to comply with the Appropriations Integrity Act -- leaving \$392 million in FY 1988. However, pursuant to language in the CR, \$225 million of that amount is not available until June 1. In reality, therefore, there is \$167 million for the space station program for the first 8 months of FY 1988, plus \$90 million of unobligated FY 1987 funding.

Question 10: Dr. Fletcher, how constrained is your FY 88 space station budget? If you had not received permission to utilize \$45 million of the FY 87 funds last Thursday, would you have been forced to terminate the space station contracts?

Answer 10: The FY 1988 budget is very, very tight. Without the FY 1987 funds, NASA would have had to issue stop work orders in early March. The \$45 million will last only for an additional six weeks or until approximately mid-to-late April.

Question 11: Do you currently have enough funds to take care of termination costs if that situation were to occur?

Answer 11: Yes, we have enough funds to take care of termination costs if that situation were to occur.

Question 12: By what date is it critical for the remaining \$45 million in FY 1987 funds to be released?

Answer 12: NASA must receive the remaining \$45 million in FY 1987 funds in April if it is to avoid issuing stopwork orders to its contractors.

Question 13: Is it fair to say that in FY 1988 you have no contingencies and little or no flexibility? What about in 1989 -- does the request contain any contingencies or provide any flexibility?

Answer 13: Yes, NASA has very little flexibility and no contingencies in the FY 1988 budget. In FY 1989 there is a contingency (or reserve) of less than 3 percent. The bulk of Space Station reserves are in the outyears when hardware advanced development, integration and testing are underway.

Question 14: Dr. Fletcher, will any metal be cut in FY 1988, or will there merely be design work?

Answer 14: In introduction to this subject, let me say that everything we are doing is directed toward the production of flight hardware, but that actually fabricating that hardware is, probably, a ways downstream. Considerable metal has been "cut" already for the various test beds. Advanced fabrication of flight hardware cannot begin until designs are complete, currently planned for 1991. Consequently, "merely" is not an appropriate adjective to apply to this very critical phase of the program. Historically, the design effort for a major space system has involved the work of thousands of skilled workers in the production of tens of thousands of precise engineering drawings that are essential to the successful manufacture and integration of the total system.

Reschedule/Rescope Report

Pursuant to the CR, NASA was asked to "rescope" and "reschedule" -- but not "redesign" -- the space station program. This report was due February 29th, but that date has slipped until April 1st.

Question 15: Dr. Fletcher, based on prior discussions, would I be accurate if I assumed there are few additional modifications or trades that could be made to the current design?

Answer 15: The current configuration is a very strong design. Numerous systems trades studies have been completed, and the results are included in the April report to Congress. In general, there are very few modifications that can be made to the current design without significantly raising life cycle costs or reducing user capabilities.

We remain convinced that the Space Station design and configuration is optimum. The NRC concluded, in its September report that the current configuration was the best alternative among

those examined and that it reflected thoughtful compromise among the priorities and requirements of early scientific and engineering users. We are considering only the minor types of systems changes that always occur during the early phases of a major space project. The budget reductions have forced a delay in the schedule which is still being assessed.

Question 16: Is it likely that the launch schedule can be accelerated to accommodate a man-tended capability in 1995? If additional money were thrown at the program, could the man-tended capability be achieved at an earlier date?

Answer 16: NASA believes it is possible to advance the schedule to allow an early man-tended capability in the fourth quarter of 1995. Since funding in FY 1988 and FY 1989 is tightly constrained, additional funding could probably accelerate the man-tended capability milestone in the context of accelerating the entire schedule. Any reduction would, of course, delay it.

Question 17: Dr. Fletcher, is it true that every 6-month slip of the program costs \$500 million?

Answer 17: Roughly, yes at this point. The exact cost of a slip depends on where in its schedule the program is. As the program proceeds to detailed design and development, the cost of a slip will increase considerably.

Question 18: Will the final "rescoped/rescheduled" space station program still be consistent with the 3-year funding request?

Answer 18: Yes, the final "rescoped/rescheduled" program will be consistent with the three year funding request.

FY 1989 Budget Request

The FY 1989 space station budget request is for \$967.4 million.

Question 19: Of that amount, how much money is for hardware? How much for engineering design? How much of this money stays within NASA?

Answer 19: Of the \$967.4 million requested for Space Station in FY 1989; \$935 million is for Research and Development. Of that, very little is for the actual hardware that will physically make up the Space Station. The majority of it will be spent on the test hardware, test beds, software development, design model hardware and engineering design. Most of the Space Station development funds go to contractors. NASA's research and program management (R&PM) account pays for the NASA civil servants working on the program.

Question 20: Based on the FY 1989 request, how much funding would be provided for each of the four (4) work package contractors -- McDonnell Douglas, Boeing, GE/RCA, and Rocketdyne? And how much of this contractor money is for hardware? Are these contractors fully staffed?

Answer 20: Boeing, contractor for Work Package 1, would receive approximately \$150 million, McDonnell Douglas, in charge of

Work Package 2, would receive approximately \$200 million, General Electric and RCA, in charge of Work Package 3 at Goddard Space Flight Center, would receive about \$40 million, and Rocketdyne, contractor for Work Package 4, would receive \$130 million. Very little of this funding will be for hardware; most of it will be used for advanced design work in support of actual Station hardware development.

The contractors are not fully staffed. Their staffing levels are currently capped, consistent with the FY 1988 funding constraints.

Question 21: Based on the FY 1989 request, how much funding will be provided for the three support contracts -- the Technical Management and Integration System (TMIS), Boeing; the Program Support Contractor (PSC), Grumman; and the Software Support Environment (SSE), Lockheed? Are these contractors fully staffed?

Answer 21: Boeing Computer Services, the contractor for TMIS, would be funded at approximately \$31 million; Grumman, the contractor for the Program Support Contract would receive approximately \$59 million; and Lockheed, in charge of SSE, would receive approximately \$36 million. These contractors' staffing levels are also capped. The rest of the development budget funds development of the Flight Telerobotic Servicer (\$20 million), various small development projects at Levels I and II of the Program (\$10 million) and center supporting development activities such as the fabrication of testbeds.

Question 22: Based on your current assessment of the program, what is the total estimated cost of the Phase I space station? How does this cost compare with the NRC estimate of last September?

Answer 22: Total development cost of the Phase I Station before the FY 1988 funding reduction was \$15.3 billion in FY 1989 dollars, which was consistent with the NRC estimate. The FY 1988 funding reduction which--along with the reduction in the FY 1989 budget request--caused a slip in the schedule of approximately a year, increased the development cost. By how much is still under review.

Question 23: Would you have a better estimate of the cost after the Program Requirements Review? When will that review take place?

Answer 23: Cost estimates always improve somewhat as experience is gained, but we do not expect that the PRR will result in significant changes to either program content or cost. The PRR will be completed this summer.

Question 24: What is the current estimate of potential foreign participation by ESA, Canada, Japan?

Answer 24: The international partners are expected to contribute over \$7 billion dollars worth of hardware to the program. We understand that ESA will spend about \$4.2 billion, Canada about \$1.0 billion, and Japan about \$2.0 billion in real year dollars. The international hardware elements thus represent a sizable

financial contribution to the program. It is also important to note that the international partners will pay a share of the operations costs of the Station throughout the lifetime of the program.

Question 25: What is the overall scale of the space station program when foreign participation is included?

Answer 25: The overall value, in terms of development cost, of the program when the anticipated foreign participation is included totals approximately \$26 billion dollars in real year dollars, of which the United States pays 73 percent.

Crew Emergency Rescue Vehicle

Question 26a: Although no monies are requested for a space station crew emergency rescue vehicle (CERV) in the space station budget for FY 1989, doesn't the Office of Space Flight's budget contain \$9 million for the CERV?

Answer 26a: Funds for Assured Crew Return Capability studies are as follows:

FY 1987	FY 1988	FY 1989
\$3M (Space Station)	\$4M (Space Flight)	\$11M (Space Flight)

Question 26b: What is the current status of the CERV program, and when will this be proposed as a new start?

Answer 26b: Responsibility has recently transferred to Office of Space Flight. We are in a concept definition phase and have established the feasibility of a station-based return vehicle option. The scope of the studies has been expanded to encompass an "Assured Crew Return Capability" (ACRC) including the following options:

- o A new ground- or space-based emergency return vehicle
- o An orbiter, modified as necessary, for extended on-orbit stay time
- o A ground-based, capable shuttle launch on need capability
- o Unmanned shuttle launch with automated or remotely controlled rendezvous/prox ops to provide reentry-capable orbiter to space station crew
- o ELV's, in conjunction with OMV, to resupply space station crew for indefinite period
- o Review possible modifications to station safe haven approach which may enhance other options.

We are currently reviewing mission requirements.

Question 26c: At what point does the space station require a CERV?

Answer 26c: Generally we have been looking at options for having an assured crew return capability at the Station Permanent Manned Capability date.

Question 27: Will the CERV be funded within the space station or space flight budget?

Answer 27: Funding for the Assured Crew Return Capability studies will be provided by the Office of Space Flight.

Question 28: What capabilities are required by a CERV?

Answer 28: The primary design reference missions involve a grounded NSTS, a Space Station emergency, and a medical emergency. The ongoing in-house studies and planned system definition efforts will identify the capabilities to satisfy these design reference missions. Generally crew return capabilities will include de-orbit propulsion and controlled descent and landing in a safe manner.

Contingencies

Much has been made of the required contingencies budgeted for the space station program.

Question 29: What is the overall percentage of the space station budget allocated for contingencies? Is this level consistent with other capital intensive government projects?

Answer 29: The Space Station budget run out — through the final assembly and check out of the Revised Baseline Configuration maintains over the life of the development program a 33% reserve (approximately 1/3 of total development costs). This level is consistent with a project of this scope and magnitude.

Question 30: How much contingency funding is there in the FY 1989, FY 1990, FY 1991 space station budget requests?

Answer 30: There is very little contingency funding in near-term fiscal years of the Space Station program — less than 3 percent of development funds. The bulk of the reserves in the program are being planned later on in the development phase of the Program. Consequently, maintaining conformity to the near-term funding/budget profile is essential.

Space Station Transportation Requirements

The Space Station Office recently did an assessment of space station transportation requirements.

Question 31: Based on that study, is the NASA space station office confident that the space shuttle can meet all of the space station assembly requirements?

Answer 31: The results of the recent Transportation study give us every indication that the STS is fully capable of providing and satisfying the transportation needs of the Program of the Space Station manned base. The polar platform may require an expendable launch vehicle.

Question 32: Based on that study, isn't it also clear that a new Advanced Solid Rocket Motor would be a significant asset to the space station program?

Answer 32: There is no question that the Advanced Solid Rocket Motor (ASRM) will be valuable in improving the efficiency of the

Shuttle in transporting Space Station elements to orbit. However, it remains clear that the Station can be assembled using the existing capabilities of the STS.

Metric Vs. Standard

NASA recently announced that it had rejected use of metric weights and measures on the space station because of safety concerns.

Question 33: Could you please inform the Subcommittee of the extent of the analysis made by NASA before the metric system was rejected? Is it true that use of metric would add a 10 percent cost penalty to the U.S. portion of the space station program?

Answer 33: A significant amount of analysis was done early in the program regarding the possible benefits of using the metric system on the Space Station. It was concluded at that time that there would be an additional cost associated with the use of metric since the U.S. aerospace industry works on standard units. In light of the recent DOD decision to use metric, NASA is reevaluating the data and will complete its examination in May.

Question 34: Were U.S. industries, large and small, including tool and dye makers, etc, consulted?

Answer 34: In making the decision regarding the use of metric on the Space Station NASA solicited views of Space Station contractors. It was felt that if Space Station went metric, this one program would bear the entire cost of converting many contractors to the use of metric. In light of the recent decisions by SDIO to use metric the decision is being reevaluated.

Question 35: Why is it that the recent U.S./European SDI agreement utilizes the metric system but the space station agreement doesn't.

Answer 35: In light of the recent decision by SDIO regarding the use of the metric system, the Space Station program is reevaluating its position. We will make a final decision in May of 1988.

Question 36: Is NASA reassessing its decision, and when will a final decision be made?

Answer 36: In light of the recent decision by SDIO regarding the use of the metric system, the Space Station program is reevaluating its position. We will make a final decision in May of 1988.

Polar Platforms

The current space station proposal assumes that the U.S. and ESA both will contribute polar platforms to the space station program.

Question 37: Is this assumption still correct?

Answer 37: Yes, both the U.S. and ESA will contribute polar platforms.

Question 38: With the loss of space shuttle launch capabilities from the West Coast into polar orbit, will a "serviceable" polar platform still be developed? How would such a facility be serviceable by a robot, and has any budget allotment been made for this type of robotic capability?

Answer 38: Technical studies are also being done to look at the feasibility of using unmanned launch vehicles and telerobotics to service the platforms. The Space Station program is also currently conducting trade studies to determine the relative utility of developing and using such an automated servicing capability as opposed to launching non-serviceable platforms. In either case the U.S. polar platform will make use of Space Station "common" systems.

Question 39: Isn't ESA seriously considering a "non-serviceable" polar platform?

Answer 39: Yes, it is.

Commercialization of the Space Station

Consistent with the new Space Policy, the NASA budget justification states that "NASA will, in consultation with OMB, revise its guidelines on the commercialization of space station..."

Question 40: What are the current NASA guidelines for commercialization, and what types of revisions are being assessed?

Answer 40: The current guidelines are as follows:

1. NASA welcomes and encourages participation in Space Station development and operations by U.S. commercial enterprises which seek to develop with private funds Space Station systems and services.
2. NASA will entertain proposals for commercial development and operation of Space Station systems and services with the goal of achieving agreements between NASA and the enterprise.
3. Agreements shall be for specific services with responsibilities and interfaces clearly defined and shall be focused on achievement of objectives in specific time periods.
4. NASA will provide, where appropriate, incentives to the enterprise.
5. NASA safety standards will be applied where appropriate; standards such as reliability and quality assurance will be applied based on criticality to Space Station functions.
6. NASA will protect proprietary rights; and will ask for privately-owned data only when necessary to carry out its responsibilities.
7. U.S. commercial enterprises may, where appropriate, enter into agreements with NASA to receive technical assistance, including access to NASA data and facilities.

8. U.S. commercial enterprises will retain responsibility for sustaining engineering, operational support, financing and spare parts for their services.

9. U.S. commercial enterprises may offer their services to Space Station participants.

The revisions required by the President's Commercial Space Initiative will clarify and strengthen the guidelines, and in particular, will include the criteria NASA will use to evaluate private sector proposals.

Question 41: Do these revisions result in any budgetary savings compared to the current baseline, or are they for activities and services yet to be budgeted for?

Answer 41: It is impossible to assess the impact a revision of the guidelines, in and of itself, will have on the overall budgetary requirements of the Program. NASA hopes that the revised guidelines will encourage effective, productive and meaningful commercial investment and involvement in the Space Station. It is possible the resulting commercial activity could produce budgetary savings.

Question 42: What future space station requirements are being assessed by NASA that would be candidates for private sector involvement?

Answer 42: NASA is revising its Space Station commercialization guidelines in order to encourage private sector involvement. It is, however, up to industry -- not NASA -- to develop specific concepts which they believe will be profitable. All proposals will be carefully and positively considered, consistent with the policy expressed in the President's Commercial Space Initiative.

Anomaly Resolution/Rogers Commission Activities

The NASA budget request for anomaly resolution/Rogers Commission activities was held harmless by OMB during the FY 1989 NASA budget review. However, NASA's request preceded a series of problems with boot rings, bolts, welds and tests.

Question 43: How much money is contained in the FY 1989 request for anomaly resolution activities? What specific activities are funded?

Answer 43: a) Anomaly Resolution activities total \$73 million in FY 1989.

b) SRB redesign and SRB reuse activities, completion of Category 1 orbiter mods, fixes on the SSME MCC and bearings, landing aids for various contingency sites, and FMEA/CIL reviews.

Question 44: How much money is contained in the FY 89 request for activities associated with implementation of the recommendations of the Rogers Commission?

What specific activities?

Answer 44: a) In FY 1989, the OSF request contains 518 million for Rogers Commission recommendations.

b) Specific activities include SSME engine testing, SRM X-ray, additional KSC manpower for vehicle processing, added orbiter sustaining engineering, added systems and payload integration, STA-4, SCA-2, Crew Escape system, and various safety related hardware mods.

Question 45: In light of recent problems and delays associated with the return of the space shuttle to flight status, is the FY 1989 budget request still adequate?

Answer 45: The FY 1989 amounts are very tight, particularly for the Solid Rocket Booster program, although they should be adequate assuming a successful test program in FY 1988 and FY 1989.

Question 46: What about the FY 1988 budget, are there enough funds to meet the pre-flight requirements, or is the account marginal?

Answer 46: FY 1988 is very tight but manageable. The program is aggressively implementing the recovery program, and there is little flexibility remaining to accommodate unforeseen problems.

Question 47: How many additional tests of space shuttle hardware are scheduled for FY 1989? What is the budget request for this test program?

Answer 47: a) The major elements of the total program are the SSME testing which will be at a rate of 8 per month and the SRM, with one qualification motor firing (QM-8), and one flight support motor firing (FSM-1).

b) The budget request in FY 1989 contains about 73 million for the SSME testing and about 28 million for the flight support motor program, and QM-8 firing.

Cost of the Space Shuttle

In the aftermath of the Challenger tragedy, the fixed costs of space shuttle operations have increased dramatically as a result of additional processes, procedures, and safety requirements being added to the flight regime.

Question 48: What is NASA's best estimate of the direct cost of a space shuttle launch at the rate of 7 launches/year? 10 launches/year? 14 launches/year?

Answer 48: Once a steady state flight rate of about 14 missions per year is achieved, we estimate the average cost per flight in FY 1986 constant dollars to be \$272.5 million, \$202.9 million, and \$156.3 million for 7, 10, and 14 annual launches respectively. These estimates exclude the shuttle share of R&PM or network support, but include all the activities funded under shuttle operations.

Question 49: What is the current cost of each of the major flight hardware elements for each space shuttle launch -- the 3 main engines, 1 external tank, and 2 solid rocket boosters -- and how does that cost compare with the cost of the Flight 51-L hardware?

Answer 49: a) The current acquisition cost of three main engines is \$120.4 million. A new flight set of boosters is estimated at \$93-95 million, while a flight set using refurbished hardware is \$40-42 million. An external tank costs \$34 million.

b) For flight 51-L, the acquisition cost of 3 main engines was \$111 million. One external tank costs \$22 million. A flight set of solid rocket boosters, using new hardware, was \$70.9 million while a flight set with refurbished hardware was \$27.6 million.

Question 50: What is NASA's best estimate of the current fixed base for the space shuttle program?

Answer 50: Shuttle production activities are virtually all fixed, since they provide required program capabilities. Within shuttle operations, once flights resume and a steady-state flight rate of 14 launches per year is achieved, we estimate that the fixed base in FY 1986 constant dollars is about 1.7 billion which is approximately 76 percent of the shuttle operations costs. This fixed base is primarily in the manpower intensive areas like launch processing and flight operations. In addition, the engineering, management, and support manpower on the major hardware projects, like the external tank and solid rocket boosters, are mostly fixed.

Question 51: Due to the significant reduction in the proposed space shuttle flight rate -- from a proposed 24 per year in 1986 to a proposed 14 per year in 1988 -- are there any future economies of scale in the space shuttle program?

Answer 51: Yes. If the outyear funding for shuttle operations were converted to constant year dollars, it would be seen that the annual funding is fairly constant, even though the launch rate is increasing. With the high fixed base associated with manned space flight, there remains a significant economy of scale to be realized through increasing the flight rate within limitations of the system.

NASA/Morton Thiokol Contract

Last year, when this Subcommittee held its space shuttle oversight hearing on January 22, 1988, Mr. Thompson indicated that NASA was in contract negotiations with Morton Thiokol. He also indicated that Morton Thiokol would receive no fee for any work related to the redesign of the solid rocket motor.

Question 52: Have NASA and Morton Thiokol entered into a final contractual agreement?

Answer 52: An agreement was reached January 14, 1988, which resolved the contract issues, but the actual written agreement is still in preparation, and is expected to be signed within the next few days.

Question 53: Why is it taking so long?

Answer 53: The issues are exceedingly complex, with a total restructuring of the contract. An agreement in principle (MOA) was signed in February 1987, and MTI provided a proposal in June 1987. Negotiations began in October 1987 and a general agreement was reached in January 1988.

Question 54: Am I correct that NASA will pay no fee for SRM redesign activities?

Answer 54: The SRM redesign is currently estimated to cost \$605 million. Redesign activities involving the field joints, reworking existing hardware included in the redesign and replacement of the reusable hardware lost in the Challenger accident, will all be done with no fee. This work involves approximately \$505M. NASA will, however, pay a fee for NASA directed safety enhancements such as a new X-ray facility, process controls, and parallel design activities.

Question 55: Can you estimate the value of that fee and has the new contract been restructured to place emphasis on performance?

Answer 55: Maximum potential fee is \$48.2 million on approximately \$446 million of work (10.8 percent). Performance will be graded every six months, with fee reductions for poor performance.

Space Flight Reimbursables

Prior to the Challenger disaster, the NASA space flight budget was a source of considerable reimbursables for space shuttle and ELV launch services provided for government and commercial payloads. As a matter of fact, one of the reasons for the growth in the space shuttle budget is the loss of these offsetting receipts.

Question 56: What is the level of shuttle reimbursables in FY 1989? Does that number grow in the outyears?

Answer 56: About \$12 million is anticipated in FY 1989 reimbursements (commercial). Outyear reimbursements grow in the outyears principally because of DOD. "Approved" reimbursable customers are included in budget planning and can be accommodated within the flight rate, although the launch dates may not be the most desirable to them.

Shuttle Operations Reimbursements

FY 1989 Budget

	<u>FY 1988</u>	<u>FY 1989</u>	<u>FY 1990</u>	<u>FY 1991</u>	<u>FY 1992</u>	<u>FY 1993</u>
Reimbursements						
DOD	<u>0</u>	<u>12.4</u>	<u>92.4</u>	<u>425.4</u>	<u>329.1</u>	<u>406.8</u>
		-	(82.4)	(392.5)	(307.5)	(406.8)

Question 57: Who are the potential "paying customers" for space shuttle services, and which of these customers have slots on the manifest?

Answer 57: "Paying customers" included for budget planning:

SKYNET - British
EURECA - ESA
SYNCOM - Navy/Hughes
SATCOM - RCA
INMARSAT
ISF - Shuttle II (SSDA)
GEOSTAR (SSDA)
S/L-J - Japan
S/L-D2 - Germany

Question 58: Has DOD reduced its space shuttle usage from 8 of 24 scheduled flights per year prior to Challenger to 2 of 14 scheduled flights per year based on the current manifest?

Answer 58: Because of the backlog in DOD missions, the budget includes 8 DOD flights in FY 1989-1990. Although the DOD flight rate fluctuates some, after that, the annual average after FY 90 is about 2 flights per year.

1989 Budget Planned Flights

	1989	1990	1991	1992	1993
DOD	<u>3</u>	<u>5</u>	<u>1.6</u>	<u>2.7</u>	<u>2.0</u>

Question 59: At what point in time will DOD have used the 9 space shuttle flights they have already paid for?

Answer 59: As planned in the FY 89 budget, the DOD uses up the 9 flight credits after their first flight in March of 1991.

Question 60: Has DOD scheduled any new space shuttle missions since Challenger? How many payloads has DOD off-loaded?

Answer 60: The DOD requested flight space for CIRRIIS, TEAL RUBY or IRSS which NASA is attempting to incorporate on one STS mission in FY 1990. Through FY 1992, the DOD has offloaded and/or deferred about 11 STS equivalent flights, (plus the mission added above) since the NASA FY 1988 budget planning.

Question 61: How many ELVs has NASA requested from DOD pursuant to the Air Force/NASA quid pro quo? How many shuttle flights has DOD requested pursuant to the quid pro quo?

Answer 61: The DOD has stated that they will provide 2 DELTA MLVs (for ROSAT & EUVE in FY 1990 & 1991) and they are planning to provide a TITAN IV (for a planetary backup) in 1991. All DOD shuttle flights are assumed to be on the basis of the quid pro quo, per the NASA/Air Force Memorandum of Agreement (MOA).

Advanced Launch Systems/Shuttle-C

The FY 1989 NASA budget request contains \$13 million in new monies for the Advanced Launch System (ALS) program. NASA also assumes that DOD will transfer an additional \$55 million for the ALS program to NASA for propulsion activities pursuant to a recent agreement. No monies are contained in the NASA budget request for Shuttle-C although NASA did request \$145 million from OMB.

Question 62: Are there any NASA missions that require the heavy lift launch capabilities advertised by the ALS or Shuttle-C -- 80,000 to 150,000 pounds to low earth orbit? Are there any DOD missions?

Answer 62: The \$55 million referred to above for FY 1989 DOD transfers to NASA for ALS is not firm, and has not yet been negotiated. Outyear funding is also unknown, at this time. There are no NASA missions currently under study that will require the heavy-lift capabilities offered by ALS or Shuttle-C.

The Shuttle-C concept studies are part of the overall ALS activities. There may be future missions that could benefit from such a capability but the scope and timing of these potential missions are unknown at this time.

- o Mission to Planet Earth (large GEO platforms)
- o Unmanned Planetary Exploration Missions, like CRAF, MRSR would benefit from heavy lift vehicles.
- o Manned Lunar & Mars missions.

In addition, Space Station assembly flights, assembly period timespan and EVA assembly requirements could be significantly reduced by Shuttle-C (ALS would not be helpful because of timing.) DOD projects requirements for large GEO platforms and SDI payloads.

Question 63: Based on the President's FY 1989 budget submission, has the ALS program been realigned from a heavy lift launch vehicle development program to a fundamental research and development program?

Answer 63: Development decision has been deferred. Definition studies and a focused technology program are planned.

Question 64: Does this change alter NASA's perceived role in the ALS program?

Answer 64: NASA's role as the lead for liquid engine systems and Focused Technology Programs remains unchanged.

Question 65: Does NASA intend to use any of the \$13 million requested in the NASA budget in FY 1989 for the Shuttle-C program?

Answer 65: No. The ALS funds provide for the initiation of definition studies dealing with unique civil requirements which build on ALS baseline design studies on civil payload/mission requirements, propulsion, stage/vehicle systems, and support

equipment. In addition, trade and definition studies will be conducted to determine the most cost effective means of supporting non-standard spacecraft and payloads.

Crew Escape Systems

The FY 1989 budget contains \$9.7 million for crew escape systems, and the FY 1990 and FY 1991 NASA budgets assume \$16.3 million and \$50 million, respectively.

Question 66: Is the FY 1989 request adequate, regardless of the type of crew escape system incorporated into the Space Shuttle?

Answer 66: FY 1989 funding of 9.7 million may not be adequate to fully implement the first phase of the crew escape system, covering gliding flight. Due to a delay in deciding on which extraction method (rocket vs. pole) to employ, a cost increase may be incurred. The vehicle hatch modifications, along with either an escape pole or a tractor rocket system will complete development in FY 1988 and be incorporated on STS 26.

Question 67: Why does the proposed funding increase so dramatically in the FY 1991 budget? Won't all three existing orbiters be equipped with a crew escape system before then?

Answer 67: In FY 1990 and FY 1991, funds are included for the second phase of a crew escape system, covering ascent-powered flight. The specific design to be incorporated is not yet known.

Structural Spares

Prior to Challenger, this Subcommittee was advised a spares program did not exist that could support the proposed flight rate. Prior to Challenger, this Subcommittee also had wisely invested in a set of space shuttle structural spares that has served as the basis of the new orbiter.

Question 68: How much money has NASA requested in FY 1989 for the various spares programs — orbiter spares, lay-in spares, structural spares?

Answer 68: Please refer to the attached spares funding chart.

SPARES FUNDING

<u>ORBITER</u>	<u>87.4</u>	(Shuttle Production)
Lay-In	4.8	
Rate	25.3	
Structural	57.3	
<u>SSME</u>	<u>21.0</u>	(Shuttle Production)
Engine # 2031	9.8	
Engine # 2036	11.9	
(4th SSME under OV-105)	(10.9)	(FY 1989 cost)
SSME Spares	24.1	

Question 69: What is the total estimated cost of the proposed structural spares program, and has NASA changed its view as to the critical elements of this program?

Answer 69: The total cost of the proposed structural spares program is approximately \$475 million. NASA has not changed its view as to the critical elements of this program nor the purposes for which it is intended. The spares serve to maintain the capability at major contractors to produce orbiters; they serve to reduce the time to repair a vehicle in case of damage to a structural member; and they serve to reduce the time to produce an additional orbiter. In order to assure that the optimum complement of hardware is ordered, NASA is analyzing the current hardware lead times and production requirements.

Question 70: Do all of the required structural spares program subcontractors still exist, or would new subcontractors have to be qualified? Is all of the necessary tooling still available?

Answer 70: The major subcontractors do still exist, and having to qualify new contractors may be necessary, if the existing subcontractors no longer choose to participate.

Question 71: Are structural spares a high priority in light of the severe budgetary pressures?

Answer 71: Initiating a new set of structural spares in FY 89 is critical, if we are to maintain a national capability to build future orbiters. In addition, structural spares must be available, if structural damage occurs on one of the existing orbiters, in order to minimize the downtime and effect on the flight rate.

Question 72: Why won't the logistics depot at KSC be completed until FY 1991?

Answer 72: Due to the reduced mission model, it was decided by KSC that a deferral of this activity was prudent in order to help offset growth in other areas.

EDO/OMV

The space transportation capability development account includes \$10 million in FY 1989 for an Extended Duration Orbiter approved by the Congress in FY 1988 and \$96.5 million for an Orbiting Maneuvering Vehicle.

Question 73: What are the total estimated costs of both of these initiatives? And the proposed budget run outs?

Answer 73: Please refer to the chart below:

	<u>FY 1989</u>	<u>EAC</u>
EDO	10.0	126.0
OMV	96.5	539.7

Question 74: By what date does NASA require both of these

capabilities? For example, what is the first mission that requires an OMV?

Answer 74: For EDO, NASA intends to release an RFP later this year for the cryo pallet, which includes:

DDT&E
1 flight vehicle
STS integration
Flight control systems at JSC
KSC processing/launch support

First launch requirement for the EDO is not yet defined, but space station assembly and logistics operations are candidates. The cost of the OMV is \$541.6 million. The first flight is scheduled for June, 1993 and depending on the orbit state of the Space Telescope, it will support that requirement of a highly desirable demonstration mission with a plasma physics payload yet to be selected.

Question 75: Has NASA decided whether or not to commercially compete the EDO? Did the Department of Commerce do a study that inferred it was cheaper for NASA to build the EDO instead of leasing a commercial EDO?

Answer 75: We are not aware of any such study.

New Orbiter

The FY 1987 NASA appropriations bill provided full funding, \$2.1 billion for a new orbiter. Pursuant to that approval, NASA signed a contract last August with Rockwell for the construction of a new space shuttle orbiter. Since that time, however, congress has been forced to dip into that pot of money for \$100 million to keep the space station alive in FY 1988 and for \$125 million for additional FY 1988 shuttle anomaly resolution activities.

Question 76: What is the current status of the new orbiter contract? And when will the new orbiter be delivered to NASA and ready for flight?

Answer 76: The contract with Rockwell has been signed and delivery to KSC is expected in May 1991, with a first flight in late 1991 or early 1992. The SSME deliveries have been negotiated consistent with these dates.

Question 77: What level of activity already has occurred, and how much money will be spent in FY 1988? in FY 1989? in FY 1990?

Answer 77: Please refer to the attached OV-105 funding chart.

OV-105

<u>Obligations</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>Total</u>
Initial Appns	2100.0			2100.0
Space Station	-100.0			-100.0
FY 1988 Approp.	-125.0			-125.0
<u>Costs</u>	<u>50.4</u>	<u>439.1</u>	<u>670.7</u>	<u>1875.0</u>

Orbiter Base	44.6	330.3	530.7	1307.8
Support		23.7	26.5	89.1
SSME	3.0	24.5	49.6	196.7
DCAS	2.8	2.6	3.6	10.7
APA		58.0	60.3	270.7

Question 78: Due to the Congressional action on the CR, is there enough money in the orbiter account to complete the program, or will additional funds be required?

Answer 78: There should be sufficient funds to cover negotiated costs as well as anticipated changes. However, further reductions could jeopardize the program and its ability to implement necessary changes.

New Shuttle Carrier/New Training Aircraft

The FY 1989 budget indicates that funds are provided for a new shuttle carrier and a new training aircraft.

Question 79: How much money is requested for each of these items in the FY 1989 budget request, and what's the total estimated cost of both vehicles?

Answer 79:

SCA-2/STA-4

	1988	1989	1990	TOTAL
SCA-2	19.7	22.0	13.3	55.0
STA-4	0.8	15.8	1.5	18.1

Main Engine and Solid Rocket Motor Improvement

NASA has supported a program to upgrade the space shuttle main engine and its components for several years. But NASA has not had a similar program for the solid rocket motor.

Question 80: What is the level of effort of the Pratt & Whitney SSME contract in FY 1989? What additional funding is provided to Rocketdyne for main engine testing and improvements?

Answer 80:

<u>PRATT & WHITNEY</u>	<u>FY 1989</u>
Alt Turbo Pump	65.1
<u>ROCKETDYNE</u>	<u>220.1</u>
Testing	180.9
Prod Improvements	39.2
(External HEX	(3.8)
(Other PI	(35.4) (Blade Cracks, weld defects, & bearings)

Question 81: Does NASA intend to implement one of the major recommendations of the Stever Panel and establish a Solid Rocket Motor Improvement Program? Are any funds provided for this activity in FY 1989?

Answer 81: We have added funding to support a continuation of full scale testing at 2 firings per year. The FY 1989 cost is estimated to be \$23 million.

Physics and Astronomy

The FY 1989 request for Physics and Astronomy represents a 30 percent increase over FY 1988. The FY 1989 request includes a "new start" for the Advanced X-Ray Astrophysics Facility (AXAF)--the third great observatory, and a significant increase for the Global Geospace Science Mission.

Question 82: Due to the severe budget pressures facing the Congress, why should it approve any new starts in FY 1989?

Answer 82: (1) All currently approved missions will be launched by 1993. (2) What we start today will fly in mid-1990's, (3) No new starts today will create hiatus in space science in mid and late-1990's.

Question 83: What is the basic purpose of the AXAF mission, and what is the total estimated cost for this program that only requests \$27 million in FY 1989? What is the proposed budget run out?

Answer 83: (1) AXAF is X-ray Great Observatory, (2) 100 times more sensitive than any previous/planned mission, and (3) runout cost is \$1540-1700 million, real year dollars.

Question 84: What is the current status of NASA's down-selection of a contractor for the AXAF program?

Answer 84: Underway.

Question 85: What are the current status and proposed FY 1989 funding levels for the High Resolution Solar Optical Telescope, Gravity Probe-B, and the Solar Infrared Telescope Facility?

Answer 85: Current status: (1) HRSO under consideration for FY 90 new start as free-flyer, (2) GP-B will have engineering test flight on shuttle in FY 91, (3) SIRTf candidate FY 1992 or FY 1993 new start. Proposed FY 1989 funding: (1) HRSO \$4 million, (2) GP-B \$22 million, (3) SIRTf \$4.5 million.

Question 86: When would these programs be candidates for new starts, and what is their order of priority?

Answer 86: Several missions under consideration for new starts: CRAF/Cassini, EOS, SIRTf, HRSO, GP-B, LPO. Order will depend on available budget.

Global Geospace Science (GGS)

GGS was the only new start approved in the FY 1988 budget, and it represents the U.S. contribution to the International Solar Terrestrial Program.

Question 87: What is the FY 1989 budget request for GGS and what is the total estimated cost of the U.S. contribution to the program which consists of 2 satellites, 4 launch vehicles, and many key instruments?

Answer 87: (1) FY 1989 request for GGS - \$101 million, (2) runout for GGS S/C and instruments - \$390-440 million, (3) 2 launch vehicles - \$114 million, (4) ISTP also includes COSTR (U.S. instruments on SOHO/Cluster/Geotail) - \$240 million, (5) Tracking and Data/Operations - \$62 million.

Question 88: Does GGS have a restricted launch window? What would be the consequences to this program if the FY 1989 request were reduced?

Answer 88: (1) No restricted launch window, (2) Reduced request may cause a delay; loss of overlap with other international programs.

Hubble Space Telescope (HST) and Gamma Ray Observatory (GRO)

HST is scheduled for launch in 1989 on the space shuttle, and GRO is scheduled for launch in 1990 on the space shuttle.

Question 89: What is the current status of both of these programs? Are there any potential FY 1989 budget increases associated with either of these programs? How much funding and schedule flexibility are there for these two great observatories?

Answer 89: Both programs in good shape; no other problems anticipated.

Planetary

The FY 1989 request for Planetary Exploration is \$404 million or 23 percent greater than the FY 1988 NASA budget. Included in the FY 1989 request is a substantial increase for the Mars Observer mission scheduled to be launched in 1992 and a significant reduction in the Magellan mission scheduled to be launched in 1989. The only new start candidate for FY 1989, the Comet Rendezvous Asteroid Flyby or CRAF mission, was rejected by OMB.

Question 90: What is the overall status of the Nation's planetary program, and does CRAF continue to be the highest priority, or are Cassini and Lunar Polar Orbiter likely to supplant CRAF?

Answer 90: (1) Program in reasonable shape-Magellan/Mars Observer/Galileo, (2) Actively considering combined CRAF/Cassini new start for FY 1990--a Mariner Mark 2 program, (3) Lunar Orbiter must await 1992 launch of Mars Observer in order to utilize MO spares.

Mission Operation and Analysis

The FY 1989 Mission Operations and Analysis request represents a significant increase over FY 1988?

Question 91: Is this increase to cover the cost of the Voyager encounter with the planet Neptune in 1989?

Answer 91: Principal increase due to Voyager/Neptune encounter and beginning of Magellan operations.

Instrumentation

There has been much discussion lately about the Space Station program and the recently proposed Commercially Developed Space Facility. However, there has not been as much discussion about the required instrumentation and equipment required for these facilities.

Question 92: How much funding is included in the FY 1989 OSSA budget for instrumentation and equipment?

Answer 92: \$25 million in microgravity; develops six facilities for use on Spacelab/CDSF/Space Station; \$7.5 million to begin development of 1.8 meter centrifuge for life sciences.

Question 93: Will all of this equipment be compatible with the Spacelab, space station or commercially developed mini-space station?

Answer 93: Yes.

Question 94: Will any of this equipment be fully automated?

Answer 94: No, we believe it is essential to be able to use Spacelab/CDSF in man-tended mode. Laboratory sciences require man-in-loop at this stage of their development.

International Space Year

1992 has been designated as the International Space Year. It's also the 500th anniversary of Columbus' discovery of America and the 75th anniversary of the Bolshevik Revolution.

Question 95: Is the Office of Space Science and Applications planning any missions or activities in 1992 in conjunction with the ISY?

Answer 95: Several on-going programs support ISY goals, e.g., (1) International Solar Terrestrial Physics Program, UARS and Topex will fly s/c in 1992, (2) Scout initiative in Explorer program will launch international Scout-class missions in this time frame.

Question 96: What types of activities are being considered by international organizations and coordinating committees?

Answer 96: International organizations are coordinating on-going activities including research and education; NASA is leader in this effort.

Office of Exploration

As a result of the recommendations of the Ride Report, a separate Office of Space Exploration (OEXP) was created within NASA.

Question 97: What is the role of this Office, and how does it interact with the Office of Space Science and Applications?

Answer 97: The Office of Exploration has been formed to provide recommendations and alternatives to support a presidential decision on a focused program for human exploration of the Solar System. To achieve this goal, the OEXP will conduct mission studies and analysis of Potential exploration scenarios. Through these scenarios the Office will define the Pathfinder technology requirements necessary to enable and support a range of future exploration missions.

OEXP will interact with OSSA in two primary areas. First, OEXP will coordinate with OSSA to identify precursor and prerequisite science requirements related to the range of exploration missions. Secondly, OEXP will work to understand the science and applications potential for exploration opportunities.

Question 98: What types of mission are being assessed by the Office of Space Exploration?

Answer 98: Currently the OEXP is focusing on candidate mission scenarios related to activities that could be conducted at a Lunar base, missions for a humans to Mars mission, and the potential of utilizing a Lunar landing program as a stepping off point to establish a Mars base.

In developing these scenarios OEXP is identifying the precursor technology requirements that will enable mission decisions (particularly related to the Pathfinder Program); identifying the life science research program that must be initiated to permit safe, productive stay times for long duration in orbit; providing an understanding of issues associated with zero-g and artificial-g flight; understanding the evolution necessary for the Space Station to support human exploration initiatives; and identifying the Earth-to-orbit transportation requirements and associated transportation needs.

Question 99: Will this Office propose candidate missions to implement the President's directive to expand the presence of man beyond LEO?

Answer 99: Yes, OEXP is currently targeting a mature understanding of program options for a Presidential decision on a focused program of manned exploration of the solar system.

Question 100: Are there currently any discussions underway between the U.S. and Soviet Union to initiate a Mars Sample Return Mission or any other major cooperative space venture?

Answer 100: We are currently cooperating with the Soviets in solar system exploration under the 1987 space agreement. While the activities being pursued in this framework do not include joint missions to Mars or any other destination, they do include cooperation in potentially related areas such as the study of potential future landing sites on Mars.

We believe that it is premature to discuss joint missions for a variety of reasons. First of all, in the specific context of U.S.-Soviet cooperation, we need to build a tradition of success in a progression of more modest activities of the sort being pursued under the space agreement.

Second, NASA is currently studying what our next objective should be in the exploration of the Solar System. We have not yet settled on what our objectives should be, or on the specifics of the mission. A great deal of technology development remains to be done to support whatever decision is made.

In the meantime, we are undertaking cooperative projects to enhance the return from independent U.S. and Soviet missions to Mars. In particular, we have agreed in principle to accommodate a Soviet radio receiver on the Mars Observer spacecraft. Radio signals from the atmospheric balloons to be delivered to Mars by the Soviets' proposed 1994 mission to Mars (in conjunction with the French) would be relayed to earth by the Mars Observer's data system through the Deep Space Network. This U.S. contribution would uniquely enhance the scientific data return from the balloons, in exchange for which the U.S. would share all the data. Of course, the success of the proposal depends on the timing of the Soviet mission's arrival at Mars, and assumes that both Mars Observer and the Soviet receiver would still be operating at that time. Detailed arrangements have not been worked out.

Space Science Policy Issues

Balance of Large and Small Missions

There has long been a debate as to what type of space science missions get you the most bang for the buck. This debate has added significance during times of fiscal restraint.

Question 101: Does the NASA space science budget reflect the appropriate balance between big science projects such as the great observatories that cost \$1-1.5 billion and small scale science missions such as explorer missions that cost \$100-300 million?

Answer 101: Yes, AXAF, Scout Initiative, Space Station initiative are a balanced program.

Question 102: Why did NASA appeal AXAF to OMB in the FY 89 budget process--a \$1.5 billion great observatory--whereas NASA did not appeal CRAFT--a \$400 million planetary explorer mission? Is the AXAF science worth the cost of 4-5 other missions?

Answer 102: CRAFT costs about \$1 billion and has first year costs substantially higher than AXAF. Unlike AXAF, CRAFT does not fit into a level OSHA budget.

GAO Report

The Senate Commerce Committee currently has under way, a GAO investigation of 4 NASA space science missions to try and understand the reason why these missions have experienced such incredible cost increases. The 4 missions are Galileo, Ulysses, Magellan, and Mars Observer.

Question 103: Could you please explain to the Committee why such cost increases occur?

Answer 103: Most of increase due to slippages in launch dates.

Question 104: What steps are being taken by NASA to correct this situation? For example, are contract provisions being modified?

Answer 104: Mixed fleet plan, with robust launch capability should correct previous problems.

Question 105: What steps could the Congress take to force space science missions to be done at cost and on time?

Answer 105: Provide for mixed fleet and adequate funding to achieve shuttle launch schedule.

Space Station and Space Science

NASA has worked hard during the course of the last few years to maintain the support of the space science community for the space station program.

Question 106: Could you please inform the Subcommittee of the current status of that support? As the program progresses, is there a concern or perception that some scientific disciplines are winners--materials processing and life sciences--and some disciplines are losers--planetary and astrophysics?

Answer 106: Station is supported by science community, particularly by microgravity, life sciences, and earth sciences communities who are principal users. That support will continue as long as the budget provides for a balanced program.

FY 1989 request contains AXAF, Scout Initiative in addition to Space Station initiative program is balanced.

Question 107: Has NASA created a new space science advisory board for the space station? Does it represent all the disciplines?

Answer 107: Yes.

Question 108: Is it true there is no money in the FY 1989 budget for instruments for the space science polar platform and that

those instruments for the Earth Observation System will not be considered for a "new start" until 1991? What is the estimated cost of those instruments? And how will the instrument/experiment selection process be affected by the decision as to whether or not the polar platform will be serviceable?

Answer 108: There is \$15 million in FY 1989 to support selection and definition of instruments for EOS on the polar platform. FY 1991 is earliest possible start for EOS. AO is currently out. Selection by early 1989. New start proposed in summer of 1989 for 1991 budget.

Servicing is planned. Telerobotic servicing most likely. However, conceivably shuttle with ASRM available from WTR when needed.

New Space Policy

There has been much discussion about the new space policy and its emphasis on the preeminence of manned space flight. There has been less discussion about its meaning to unmanned space science activities.

Question 109: What is the Office of Space Science and Applications view of the new space policy?

Answer 109: Policy reaffirms requirement for U.S. leadership in key areas of space science and applications.

Question 110: Is there anything in this new policy of particular importance to space science?

Answer 110: The continued emphasis on leadership. CDSF could provide additional flight opportunities for microgravity.

Graduate Student Research Program

This Subcommittee is very supportive of the Graduate Student Research Program and feels that it is a critical element of the future competitiveness and leadership of the Nation's space program.

Question 111: Have any efforts been taken to expand this program in the FY 1989 request?

Answer 111: Yes, a modest expansion will occur.

Question 112: What is the estimated number of students and institutions that will benefit from this program in FY 1989, and how does this compare with FY 1988?

Answer 112: 240 students supported, agency-wide in 104 universities in 42 states in 1988 and about 265 students in 1989.

The Advanced Communications Technology Satellite

Based on an action of the Appropriations Committee, the TRW ACTS contract was terminated, and these activities were reassigned to GE Astro.

Question 113: Would you please give the Subcommittee a status report on this transition?

Answer 113: The transition of TRW contract to GE has been completed. All documents, parts, test equipment, and existing payload hardware have been successfully transferred, with full cooperation of TRW, to GE. GE has been in the process of bringing its lead engineers onboard to continue the activities previously in TRW portion of the contract. the process is progressing smoothly and as planned.

Question 114: Also, would you please inform the Subcommittee as to the exact FY 1989 funding requirements that exist for the ACTS program -- the satellite and the upper stages -- if the Subcommittee desires to continue this program?

Answer 114: The required funds in FY 1989 for the satellite is \$76 million. The required funds in FY 1989 for the upper stage is \$12.8 million.

Question 115: What is the current cap on this program, and what is the budget run out based on the Appropriations Committee action?

Answer 115: The budget run out and the Congressional cap on the ACTS program are both \$499 million.

Commercialization of the Tiltrotor

NASA has been very successful in developing and flight testing technologies in the XV-15 Tiltrotor program. Recently, there has been some discussion that the Tiltrotor should be commercialized for intercity use.

Question 116: If such a commercial venture were to occur, do you project any continuing major role for NASA, or have you essentially fulfilled your role by bringing the technology to a state of readiness for the industry to develop into a commercial product when the market warrants?

Answer 116: The focus in tiltrotor aircraft technology, as with the entire NASA Aeronautics program, is to perform research on leading edge technologies and leave the near-term development items to industry. Two areas which fall into the category of leading edge technology are aerodynamic improvement to decrease download on the wings and technology development for an advanced composite, pressurized fuselage.

Rotary Engine

In FY 1988, the funding for Aeronautics was increased by \$2 million during the appropriations budget process specifically for rotary engine technology development.

Question 117: Had you been given an opportunity to apply additional funding to the Aeronautics program, would it have been in this particular area, or would your priorities have been different?

Answer 117: NASA has identified many opportunities for additional funding in the Aeronautics Program. This is one of the many good areas.

Question 118: What is the market potential for the rotary engine?

Answer 118: The current General Aviation aircraft market for such an engine is severely depressed. However, studies have indicated that an advanced technology rotary engine would be an excellent candidate for advanced general aviation aircraft and could help resurrect this market. In addition, the rotary engine is also an excellent candidate for use as an aircraft APU and for other military applications.

National Airspace System

There is a very serious problem today with our national airspace system.

Question 119: What role does NASA play in improving the safety or capability of the National Airspace System? Are there technologies being developed by NASA that would help turn the trend toward the growing number of near misses around and provide safer flights?

Answer 119: The NASA charter includes conducting research to improve aviation safety. For conducting this research, NASA works closely with the FAA to develop advanced technology for improving aircraft operations and interactions with the Air Traffic Control (ATC) system.

In this area, NASA works closely with the FAA to apply its human factors expertise and simulation capability to develop effective traffic alert and collision avoidance systems. NASA is also working on technology for improving operational safety in severe weather, automation and reducing the effects of human error.

Question 120: What level of funding is included in the FY 1989 budget for these activities, and how does NASA interface with the FAA on these issues?

Answer 120: There is \$6 million in the FY 1988 budget. This is being augmented by \$7.5 million in FY 1989. The NASA/FAA interface is accomplished at the working level, through FAA liaison offices located at NASA Ames and Langley, and between NASA and FAA Headquarters.

Advanced Launch System

According to the agreement on the Advanced Launch System between NASA and the Air Force, the Air Force is in charge of the overall program with NASA participation, and NASA is in charge of the focused technology program with Air Force participation.

Question 121: Are there any near-term requirements or missions in NASA for such a vehicle? Has this program been reformulated to a technology program instead of a development program? And as a

result of this realignment of the program, should there be a greater management role by NASA, and does Shuttle-C surface as an interim launch option?

Answer 121: The Advanced Launch System (ALS) is a long-term heavy-lift vehicle concept scheduled for flight in the late 1990's. We have identified heavy-lift requirements which fall into three categories: 1. Planetary and Geosynchronous Payloads, 2. Assembly of Space Station including growth elements, and, 3. Human Exploration Missions. Of these, an unmanned planetary mission, Comet Rendezvous Asteroid Flyby, scheduled for 1994 could be a near-term requirement. If a heavy-lift capability were available, it might support Space Station assembly.

Technology has always been an important part of this program. With development of an operational vehicle slipping out in time, the focused technology program takes on added importance.

The role of NASA has been established in the ALS Management Plan. A NASA representative serves as Deputy Program Manager and NASA has management responsibility for the focused technology program and for liquid engine systems. NASA is satisfied with these management roles.

By direction of Congress, there is no ALS interim vehicle. If a firm near-term national requirement were identified, the Shuttle-C could be developed to address that requirement.

CSTI/Advanced Launch System

Question 122: The two programs initiated last year, the Advanced Launch System and the Civil Space Technology Initiative, include elements which appear to address the same technologies -- especially in propulsion -- as does the Pathfinder program proposed for initiation in FY 1989. Could you describe the differences in these 3 programs that, on the surface, appear to include duplication of effort?

Answer 122: CSTI focuses on developing generic design and analysis tools and advanced design concepts for future application. ALS will perform point design hardware demonstrations focused on specific ALS requirements. The Pathfinder element deals with space propulsion (LEO to GEO, LEO to planet) and involves different technologies.

National Aero-Space Plane Program

(A) Budget

In FY 1988, the Aero-Space Plane Program -- both NASA and DOD portions -- were cut by the Congress. However, in FY 1989, NASA proposes an increase from \$53 million in FY 1988 to \$84.4 million in FY 1989.

Question 123: What is the impact of the FY 1988 reduction on the overall program?

Answer 123: Nine-month schedule slip and some refocusing of program elements.

Question 124: Is a 50 percent increase justified for a program that is not time critical, and what is NASA's most recent estimate of their share of the aero-space plane technology development program?

Answer 124: The increase is based on effort moving from conceptual design to component development and test. This increase is the most efficient way to effect the change. Anything else will incur larger overall program funding requirements.

Currently, the NASA share of funding is 42% in FY 1989 with direct and indirect (people and facilities) included. The NASA share is 30 percent over entire program.

(B) Program Management

Recently you have made some changes in the management structure of the National Aero-Space Plane Program -- the management of the program is shifting from a DARPA program manager to an Air Force program manager -- still with a NASA deputy.

Question 125: Was this a planned transition in the program management? What is the purpose?

Answer 125: The Plan was always to shift the DOD lead from DARPA to the Air Force in Phase 3. This earlier shift will provide a smoother transition from Phase 2 to Phase 3.

Question 126a: Does this indicate any change in the character of the program?

Answer 126: No.

Question 126b: Is it still a technology development and flight validation program using the X-30 experimental vehicle?

Answer 126b: Yes.

(C) Goals of Aero-Space Plane Program

Question 127: NASA's primary goal in the program has been the development and validation of the technologies for a single stage to orbit vehicle, with technology benefits to hypersonic aircraft. Based on the progress to date in the program, are your goals still the same?

Answer 127: Yes.

(D) FY 1988 Cuts

In FY 1988, the Senate Appropriations Committee substantially reduced the DOD funding to the NASP program citing "concerns" of the Defense Science Board as part of the justification. In addition, they stated that NASA should fund a larger share of the program.

Question 128: Could you provide any information on the recommendations of the Defense Science Board — did the Board have concerns about the program and recommend a decrease in the funding rate?

Answer 128: The Defense Science Board strongly supports the program and recommends increased emphasis on technology maturation. The Board did not recommend a decrease in funding, in fact, they stated more funds would be required, not less.

Question 129: What impact has the DOD funding reduction had on the NASP program?

Answer 129: Nine-month slip.

Question 130: Should the NASA share of the funding for the program be increased?

Answer 130: No. Including institutional support, NASA's participation is approximately 42 percent in FY 1989 and 30 percent overall, and is in our view appropriate.

NAS/NRC Report on Decline of Technical Base

Question 131: Dr. Ballhaus, a recent report of the National Research Council found that NASA is "no longer a strong technical organization." The report stated that a tremendous increase in resources — on the order of \$1 billion — would be needed to meet NASA's mandate to support civil and defense needs. Are you familiar with this report, and if so, what is your reaction to these findings?

Answer 131: NASA has reviewed the recommendations for Space Research and Technology as made in the NRC report and we have taken the first steps towards meeting these recommendations by initiating the Civil Space Technology Initiative (CSTI) in FY 1988 and the Pathfinder program in FY 1989.

Question 132: The report states that in the past 15 years less than 3 percent of NASA's budget has been spent on space research and technology. Are CSTI and Pathfinder the response to this decline, and do these programs represent the sustained commitment on NASA's part to "regain technical leadership." Aren't these two programs a total of about 1 percent of the NASA budget?

Answer 132: The FY 1989 funding request for CSTI and Pathfinder is \$256.8 million, which is 2.2 percent of the Agency's overall budget request. We feel that these programs will begin to lead toward the long-term revitalization of the Agency's fundamental technology programs. The Agency's request for FY 1989 increases the total Space Research and Technology Program to 3.4 percent of the total NASA request. This is a significant beginning, and we feel that we have made continued progress toward that target with this budget request.

Question 133: The NRC report specifically cites propulsion as the area of greatest concern. How much is in your budget for propulsion research and development in both the CSTI and Pathfinder efforts?

Answer 133: Proposed propulsion funding for FY 1989 in CSTI is \$46.7 million. This will support technologies leading to reusable Earth-to-orbit engine components with longer life, higher performance, and lower operating costs. To provide a safe-abort capability for the Shuttle during the boost phase, we are examining alternative concepts, such as pressure-fed liquid and hybrid liquid/solids, for booster propulsion systems.

The FY 1989 budget includes \$8.0 million in Pathfinder for research and technology on orbit-to-orbit transfer vehicle propulsion systems. Both advanced chemical and electric propulsion options will be pursued.

AIA Report/Technical Erosion

Dr. Ballhaus, the Aerospace Industries Association (AIA) also released a report which contained a strategy for counteracting the declining position of the U.S. technology base. This strategy includes such items as: cooperative efforts among industry, government, academia, and stimulation of the development and application of new technologies.

Question 134: Dr. Ballhaus, are you familiar with this report, and if so, what is your reaction to the recommendations?

Answer 134: Yes, we are very familiar with the recent AIA report ("Key Technologies for the 1990s"). NASA believes that the AIA report is a comprehensive and thoughtful assessment of key technology needs and opportunities. We are supportive of the overall recommendations of the report to assign a high priority to a focused, national aerospace technology effort, and to facilitate and encourage new technology development through innovative industry and government approaches.

We are also very encouraged by the recognition on the part of the U.S. aerospace industry that all of the partners in this effort --government, academia, and industry--need to do more in the way of basic and focused long-term research and technology development.

Question 135: In your opinion, do other countries lead the United States in the application of new technologies; if so, what specific technologies would you cite where other nations maintain the lead?

Answer 135: Unfortunately, some of our foreign competitors have been much more aggressive in the application of many advanced aeronautical technologies. One striking example is the Airbus Industrie A-320 subsonic jet transport aircraft.

The A-320 incorporates advanced, high Reynolds number wing design technology that provides increased aerodynamic performance for both high-lift and cruise speed. In addition, the aircraft features composite primary structures (vertical and horizontal

stabilizers), an advanced technology not currently available in U.S.-produced civil transports.

The A-320 also offers electric fly-by-wire flight controls and an advanced cockpit with side-stick controllers; neither technology has been applied to U.S.-built civil transports.

Question 136: Are there government policies that work to the disadvantage of industry; if so, would you be able to cite specifically what these policies might be?

Answer 136: In the light of the growing cost--and risk--associated with the development and application of new technologies, one area of concern is those policies which may serve to restrict collaborative efforts among U.S. companies. While we have made progress in the past several years in encouraging joint research and development efforts, we need to be more active in convincing--and allowing--industry to undertake collaborative efforts in product development as well. The President's proposals in this area are a step forward.

NASA, in conjunction with industry, at the request of the Congress, has prepared a Civil Aeronautics Technology Development and Validation Plan which focuses on the highest leverage technologies to address the issue of high pay off technologies ready for further development. This will form the basis and framework for consideration of future NASA and industry programs to accelerate critical technologies and enhance the U.S. industry's competitiveness in the international marketplace.

Question 137: What is NASA's position on the eight critical technology areas identified by U.S. industry as critical to their competitive posture?

Answer 137: Our position is that these eight generic technology areas represent an important foundation for a wide variety of long-term civil and military aeronautical and space system applications. They are consistent with our own assessment of future development needs, complementary to on-going NASA research and development efforts in both aeronautical and space technologies, and critical to the long-term health of the U.S. aerospace industry.

For example, we have proposed augmentations in our budget request for aeronautical research and technology for FY 1989 in composite structures and advanced propulsion research--two of AIA's eight key areas. And, private sector research and development efforts in these and many of the other areas, including rocket propulsion and artificial intelligence, will complement on-going and planned NASA space research and technology development efforts such as CSTI and Pathfinder.

To ensure that NASA and industry continue to pursue the correct opportunities, we are working with the AIA and its technology subcommittees to further define research and development needs in each of these key technology areas.

Project Pathfinder

One of the three new starts included in the FY 1989 NASA Budget Request is for the Pathfinder Program -- a new space technology initiative. However, upon close inspection, it appears that the Pathfinder Program is not totally new, and it is not totally technology.

Question 138: Would you please give the Subcommittee an indication of the composition of the proposed Pathfinder Program? How much of the FY 1989 request for this initiative is for increases to activities that were ongoing in FY 1988? How much is for new initiatives?

Answer 138: Project Pathfinder is a new technology initiative planned to begin in FY 1989. Pathfinder will allow NASA to develop critical, high-leverage technologies for future missions of Solar System exploration. The program will -- over a number of years -- develop essential capabilities in the areas of exploration, operations, human in space, and transportation.

Pathfinder is technology. However, with Pathfinder NASA will achieve more than academic research. First, Pathfinder will develop key technologies to support a future National decision regarding future potential missions. Second, Pathfinder will take those key technologies to a higher level of readiness -- thus bridging the "readiness gap" and allowing future flight project managers to make the decision to incorporate high-leverage technologies without incurring unacceptable levels of programmatic risk.

While it is new, Pathfinder -- like most NASA new starts -- is built upon a solid foundation of expertise, mission needs and ongoing, discipline-oriented technology programs. Thus, to some extent, most of the programs in Pathfinder are outgrowths of earlier -- generally very low level -- research work within NASA.

In real terms, the only portion of the FY 1989 request that will represent a substantive increase for an activity that is ongoing in FY 1988 is in the specific area of Space Nuclear Power. Some \$10 million is being invested by NASA in SP-100 in FY 1988 from existing programs; that amount grows to \$30 million in FY 1989 -- all of it as part of Pathfinder.

Question 139: What was the composition of the request for Pathfinder that NASA submitted to OMB, and how does that compare with the final budget request?

Answer 139: The budget request submitted to OMB for Pathfinder was for \$120 million for FY 1989. In absorbing the reduction down to \$100 million, NASA chose not to eliminate any of these important individual programs. Instead, the reduction was spread systematically across the elements. The two exceptions to this rule were: (1) Support for "Mission Studies" which was held at \$15 million and (2) Support for Space Nuclear Power which was held at \$30 million.

Question 140: What other agencies are involved in the SP-100 program, and how do their FY 1989 levels of activity compare with

their FY 1988 levels of activity? Is there any mission on the NASA books that requires the SP-100 program?

Answer 140: SP-100 is a joint program among the DOE, the DOD, and NASA. In FY 1988, the SP-100 program was extended and descope, because of budget reductions from a planned level of \$160 million to about \$100 million, with DoE providing \$60 million, DoD \$30 million, and NASA \$10 million. In FY 1989, the total SP-100 program is budgeted at about \$120 million, with DOE providing \$60 million, DOD \$30 million, and NASA \$30 million. Again, this level represents a reduction from the \$155 million planned for FY 1989.

SP-100 is the only U.S. space nuclear reactor program in existence. The development time for a space-qualified nuclear power source for civil missions is expected to be on the order of 15 to 20 years.

A wide variety of potential future U.S. civil space missions, and in particular those that derive from the long range National goal of Solar System exploration, will depend upon the availability of space nuclear power. These might include human expeditions with long-duration surface operations at sites with extended night periods as well as robotic missions to the Outer Planets. Without the SP-100 program, these missions will either be unfeasible or economically unreasonable.

Space Shuttle Anomaly Resolution Budget

Recently, the Office of Space Flight extensively reviewed the FY 1988 NASA budget and the funding provided for anomaly resolution activities.

Question 141: Would you please inform the Subcommittee if there is adequate funding in the Office of Space Flight budget and in the anomaly resolution account for the activities that are planned prior to the launch of STS - 26?

Answer 141: Yes there is adequate budget to support STS 26 and the associated anomaly resolution activities.

Question 142: What level of contingency still exists in this account?

Answer 142: There is approximately \$17.5 million of contingency remaining. With over half of the fiscal year behind us, we feel that this will be adequate to cover any additional changes or growth that may occur.

Question 143: What unforeseen expenses have surfaced in FY 88, and is the anomaly resolution account severely strained?

Answer 143: The major activity that has needed support is the SRM. The testing of the redesigned areas has surfaced some additional analyses and redesigns which are incorporated and will undergo tests leading to STS 26. We have been able to fund these areas and as mentioned in the question on contingency, the FY 1988 budget is adequate to support these requirements.

Question 144: Does NASA intend to implement a hydroburst test as recommended in the most recent report of the National Research Council? Is there enough funding in FY 1988 to conduct such a series of tests, and what is the projected cost?

Answer 144: NASA is not considering conducting a hydroburst test before the next flight as recommended by the National Research Council (NRC). The hydroburst issue was discussed in depth at the last meeting of the NRC on March 31 and April 1st in Utah. After the NASA/Morton Thiokol position and supporting data was reviewed it was the consensus of the panel that a hydroburst test before the next flight was not necessary. It was unanimously agreed that a hydroburst test following cycling tests (with case measurements taken) would be very desirable to verify the 20 use capability of the cases. NASA is preparing plans to conduct such a test series following the next flight in FY 1989. The projected cost can be accommodated within the FY 1989 budget request.

Question 145: How do the changes to the FY 1988 activities affect the proposed FY 1989 activities and the proposed FY 1989 budget request? Does NASA require an augmentation in FY 1989 to accommodate additional testing and development activities?

Answer 145: NASA is currently developing its future fiscal year budget requirements and projects are currently developing updated requirements. While the SRB redesign and recovery efforts are experiencing some growth, NASA has the objective of accommodating any additional funding requirements within the FY 89 budget requested.

QUESTIONS OF SENATOR KERRY AND THE ANSWERS THERETO

Advanced X-ray Astrophysics Facility (AXAF)

I am particularly interested in the space science component of the NASA budget request. Our spectacular successes in space science have been a major factor in the perception of the United States as the world's technological leader. I think it is important to maintain this reputation. Therefore, I am pleased that you have included a major new science start, AXAF, in your budget request, and I want you to know that I am supportive of this initiative.

Question: Would you tell us what special strengths or features of the AXAF program led you to choose it for the new start.

Would you tell us why AXAF needs to be started now, and how it will fit into NASA's budget profile over the next several years.

We will obviously be facing some hard choices among programs in this year's budget request.

Answer:

AXAF Features

AXAF will be a space based observatory in orbit around the earth. Designed to address fundamental questions in astronomy and physics, AXAF has outstanding scientific capability for both exploration and discovery. In recognition of the scientific potential of AXAF, the National Academy of Sciences' Astronomy Survey Committee identified AXAF as the highest priority new program for both ground and space based astronomy in the 1980's.

X-ray astronomy provides witness to the "violent universe", the world of extremes of temperature and density and magnetic fields. The ultimate fate of the universe could be discovered by the careful measurement of distances to galaxies. The existence of exotic particles predicted by new supersymmetric theories in particle physics might be confirmed or ruled out by observing their gravitational effects on hot, x-ray emitting gas in galaxies. The equation of state of matter at densities far greater than any on Earth can be tested by monitoring the radiation from neutron stars.

Urgency

Along with the Hubble Space Telescope and the Gamma Ray Observatory (which are completing development), AXAF is a key element of the Great Observatories Program. Operating in concert, and complementing each other in their respective wavelength capabilities, the Great Observatories should place mankind in a unique and historical position to understand the universe. A significant overlap in the operation of the great observatories requires that AXAF be started now.

In February 1987 a new supernova (1987A), the closest and brightest one in over 400 years or since the invention of the telescope, was observed. Supernovae are among the most powerful events since the big bang which formed the universe, and heavy elements essential for

life are formed in such events. We have the unique opportunity to observe this supernova during its early stages of formation. In a few years, radiation from the supernova will be dominated by x-rays, and these observations will provide unique insight into the process of element creation. However, the x-ray emission will diminish rapidly through the 1990's and it is essential to launch AXAF as soon as possible to take advantage of this unique opportunity.

Thus far the only x-ray observations of supernova 1987A were made by the Soviets from MIR and the Japanese with the GINGA satellite. AXAF, with its capability for high resolution imaging and spectroscopy, will far exceed the capability of the other observatories. Thus, starting AXAF now will be an essential step in returning the United States to its place of leadership in x-ray astronomy, a science that was pioneered in this country.

Budget

The budget requirement for the AXAF development program in FY 1989 is \$27 million. The total projected cost fits within a constant NASA Space Science and Applications budget over this time period.

International Space Rescue

Question: I have read with interest the letter sent to the President by the Association of Space Explorers regarding a space rescue initiative and I ask that the letter be read into the record of the hearing. Dr. Fletcher, is there a record of discussions on Space Rescue and, if so, what is that record?

Answer: In 1984, the United States proposed to the Soviets that the two nations consider a joint simulated space rescue mission, to demonstrate the capability for orbital rescue. The U.S. proposal was reiterated on several occasions and has not been withdrawn.

Formally, the Soviets have not responded substantively to the proposal. We believe (based on informal discussions and other indications) that they do not find it attractive, probably because of the asymmetry between the two nations' capabilities (see below).

Question: The concept of a universal space rescue capability makes imminent good sense. Saving the lives of Astronauts and Cosmonauts who are in immediate danger in orbit is something I am sure that we all support.

What would NASA have to do in order to provide such a life saving capability?

Answer: Development of such a capability would require substantial technical analysis and actual hardware development. Preliminary evaluations and analysis based on our experience in manned space flight reveal a number of technical issues that must be addressed relative to international space rescue.

Some technical issues we foresee are:

- A. As a matter of orbital mechanics, the Soviets could not launch any existing spacecraft from the U.S.S.R. into the Space Station orbit (28.5 degrees inclination) or other orbits below 40 degrees inclination to perform a rescue. The U.S. Space Shuttle, on the other hand, could be launched into the Soviet Mir space station's orbit from Kennedy Space Center. Spacecraft of the two countries, once in their standard orbits, would not be able to rendezvous due to the large orbital plane changes that would be necessary.
- B. A universal design for a docking system would have to be developed and used by all nations involved, and would have to be integrated into existing as well as new spacecraft.
- C. Communications systems would need to be fully compatible to ensure effective verbal communications during a rescue. There is an additional need for compatibility of data/instrumentation systems.
- D. Compatible rendezvous and docking avionics, including long and short-range tracking and ranging, would be needed.
- E. Several other areas needing resolution would include compatibility of EVA suits and life support systems, hatch sizes for suited crews and spacecraft size to accommodate the number of persons in the disabled spacecraft.

Question: Is this the right time for other nations planning manned space systems to join the U.S. and the U.S.S.R. in organizing such a capability?

Answer: We can not speak for other countries in this respect, but we note that ESA's Hermes will not be ready for flight until after 1997, and plans for other systems such as the West German Saenger are still in a very preliminary stage. For the practical future, therefore, the U.S. and the U.S.S.R. will possess the only real capability, and even that is limited for the reasons mentioned above.

Question: If such a capability existed or were developed, would there be implications for the design of future U.S. systems? Would such a capability, in place, relieve certain alternative safety requirements?

Answer: As noted in the above answer, if such a capability were developed, there certainly would be a great design impact, not only on U.S. spacecraft but on those of any nation participating in future rescue agreements.

Question: Dr. Fletcher, as we look forward to the upcoming Moscow Summit between President Reagan and General Secretary Gorbachev, there are unique possibilities for us to take initiatives on this issue. I feel that this proposal provides an unparalleled opportunity for international cooperation in space and this unique timing should not be allowed to slip past without addressing international rescue.

Answer: Assuming that the only other country with potential space rescue capability at the time of Space Station completion would be the U.S.S.R., and given the record of instability in U.S. - Soviet relations, the United States would not be well-advised to rely on the Soviets to provide an assured crew return capability for the Space Station, or for other U.S. space operations.

QUESTIONS OF SENATOR ADAMS AND THE ANSWERS THERETO
Space Station

Question 1: You mentioned this morning that no matter what the level provided, you would go ahead with the Space Station Program. While I commend your sense of commitment I want to understand the implications of that statement. In that context, let me ask you two questions.

First, last year you told us that the cost of the Program escalated by some \$700 million as a result of stretch outs and redesigns required by reduced funding levels. If the Program absorbs another cut of the magnitude it took last year, what assurance can you give us that you will be able to move forward at a pace which will not escalate the overall cost to unacceptable levels?

Second, I am aware that the desired level of funding for the Space Station was initially at \$1.8 billion. This was then cut to the budget request figure of \$967 million by the Office of Management and Budget. I would like to ask you how this adjustment, if funded in full, will affect your schedule and if it will slow the work of the contractors involved in both design work and the initial hardware work?

Answer 1: Should the Space Station Program be forced to absorb a cut in FY 1989 comparable to the reduction we absorbed in FY 1988, there would be impacts to the total budget run-out estimate. History and experience with other programs indicate that reducing funding tends to stretch out schedule. With a schedule stretch - out comes increased costs for things like retention of experienced contract personnel, inefficiencies, and inflationary adjustments. Although we would make every effort to keep the impact to a minimum, a funding reduction in FY 1989 would very likely increase the run-out cost and stretch the schedule for the program.

The FY 1989 request of \$967 Million was developed with full agreement by NASA as a result of the reduction in the FY 1988 budget from \$767 million to \$425 million. As a result of the FY 1988 reduction, the First Element Launch will be delayed about one year. Much of the design and initial hardware development work planned by all of the contractors for 1988 and 1989 had to be replanned for a later time.

Question 2: You have requested a three-year authorization (\$6.1 billion) for the Space Station. Will this be tied to the proposal made by OMB that a cap be created for Space Station funding? When can we expect to see such a cap figure for Space Station funding?

Answer 2: The Space Station Program Office is currently in the process of initiating a preliminary requirements review, which will culminate in the development of a cost, schedule and technical program baseline. This should be completed by late summer, 1988, and a program cost cap would be established shortly thereafter. This cap would be predicated on receipt of a 3 - year appropriation of \$6.1 billion. The funding stability provided by a multi-year

appropriation is important, if NASA and its contractors are to proceed with the design and development of the Space Station under a total budget ceiling.

Question 3: With the Space Shuttle Program, we have already seen what happens when the original intent of a program or idea is distorted because of scale backs in design due to a lack of resources. I have already seen this same pattern developing with the Space Station Program. Can you give me some assurance that if the Congress makes a three - year commitment to this Program at this time, it will stem this process of scale-backs and design modifications?

Answer 3: The funding profile and development schedule currently in place for the Space Station Program allows the program to develop in an orderly fashion. The three-year authorization of this program would go a long way in assuring overall program stability. Currently, the most important requirement for this program is such overall stability both in terms of funding profile and the configuration. This stability will allow program activities to remain focused on critical tasks such as the systems engineering and integration efforts.

Question 4: Are you completely satisfied with the design of the Station as it exists right now?

Answer 4: The revised baseline configuration of this Space Station represents the product of years of reviews and analyses. Many internal and external review groups which have reviewed and analyzed the configuration over the past four years. During this period of analysis, the Space Station has evolved into a configuration which we believe is the appropriate starting point.

The reason for this is simple. When the President mandated NASA to develop a permanently manned facility in space, the first thing NASA did was to begin working with the potential user communities to determine the essential requirements they would levy on such a facility. It was from this set of requirements that the physical configuration of the Station evolved. Before any decisions on Space Station configuration were made, the user requirements were clearly defined, understood, and integrated. Thus, the end result of an unprecedented Phase B definition effort was a configuration capable of achieving a multitude of objectives safely, effectively, and efficiently.

The baseline Configuration Systems have also been studied intensively. During the fall of 1987, an evaluation of the design of each distributed system to identify any technology or architecture trade-off that might result in further up-front design and development savings was conducted. In most cases where significant reductions in non-recurring development costs could be made, it was shown that the reductions would be accompanied by large increases in recurring operations costs in later years. The independent review, by the NRC, found that the Station, unbalanced, was the best configuration in meeting the objectives of user communities.

The system options study concluded with a presentation to the NASA Space Station Management Council in March of this year. After evaluating the systems on the criteria of cost, schedule, safety, mass, power, development risk, operations and user impacts, it was concluded that the systems in the baseline were sound and should not be changed. This study again verified that we do have the right configuration.

Pathfinder Program

Question 5: In your FY 1989 budget, you have subscribed to the President's long-term objective of returning our country to a leadership role in space. As a means of realizing that objective, you have requested additional funding for the PATHFINDER program as a means to broaden and strengthen the technology base of the United States' civil space program. Can you give me some of the highlights of this program?

Answer 5: Project Pathfinder is an integral part of the Nation's strategy to achieve long-term leadership in space through the development of critical, high-leverage technologies. Through Pathfinder, NASA will develop technologies that will support a broad array of potential future space missions -- focused on capabilities for piloted and robotic Solar System exploration.

These include systems for the exploration of planetary surfaces, such as advanced robotic systems -- "planetary rovers" -- that will allow extended remote exploration and scientific studies of other planets. Technologies for sample acquisition, analysis, and preservation will also be developed for installation on these "rovers". Autonomous systems for space vehicles -- such as landers and orbiters -- will be developed to allow safe and effective surface exploration. For example, sensors and onboard autonomous guidance and navigation would allow exploration expeditions to land safely and precisely in areas of high scientific interest. Similarly, the capability for autonomous rendezvous and docking between diverse robotic and piloted spacecraft would substantially enhance options and performance for surface exploration.

High performance space transfer systems would also be developed -- including both improved propulsion systems and more exotic techniques such as using the atmosphere of the Earth or another planet to change spacecraft trajectories. Advanced engines and thrusters -- both chemical propulsion and electric propulsion -- will be developed to increase the mass delivered at the Moon or another planet while reducing launch costs from Earth. Similarly, high-energy aerobraking (using a planet's atmosphere to reduce the velocity of an incoming spacecraft) would dramatically reduce propellant requirements.

The character and scope of future human operations on planetary surfaces will depend upon the successful development of Pathfinder technologies. For example, technology for an in situ resource processing pilot plant would make oxygen production possible on the Moon -- whether for propellant or for life support systems. Similarly, advances in surface power systems -- including both power generation with advanced photovoltaics and power storage with

regenerative fuel cells -- would make short term human operations possible on the Moon or at Mars.

Research into the technologies and capabilities needed for long-duration human operations in space are an important part of Pathfinder. Studies of the effects of space on humans over long duration missions will be complemented by the development of medical and/or technological countermeasures to those effects. Advanced extravehicular activity (EVA) suit technologies -- such as advanced gloves and portable life support systems -- will be developed to allow human exploration and operations on planetary surfaces. Similarly, more efficient life support systems could substantially reduce the flow of logistics between Earth orbit and human operations on the Moon as well as reducing mass in Earth orbit needs for piloted missions to Mars.

Space operations capabilities will be extended to support integration and staging of Solar System exploration missions from Earth orbit. These will include both storage and handling over extended period of cryogenic fluids for propellant or for sensor cooling. In addition, capabilities for in-space assembly and construction -- such as welding and the precise manipulation of large, massive structures -- would enable us to stage missions involving vehicles that are much larger than the capability of the largest Earth-to-orbit transportation system.

Pathfinder will develop technologies for advanced information systems and communications. These will include optical communications -- in which a laser beam replaces radio frequency links to allow tremendous improvements in the scientific data return from a mission. Fault tolerant systems -- including both advanced architectures and high-performance photonics components -- will be developed and applied in a wide range of applications, including onboard data processing and image processing for vehicles such as landers and rovers.

Pathfinder will provide support for the SP-100 Space Nuclear Power Ground Engineering System (GES) Project. The SP-100 program involves participation by NASA and several national laboratories. Testing of the nuclear reactor, a major part of the GES project, will be performed at the Hanford Engineering Development Laboratories. Space nuclear power technologies will be important for future outpost on other planets as well as substantially enhancing the performance for robotic missions to the outer planets.

Question 6: Some have said that the \$100 million figure for the program is a PR figure. Is this the amount that it will cost to get the program running? If not, what is your best estimate of the cost to launch such a program? In addition to the initial costs, can you give the committee some kind of idea what a program like this will cost over the next five or six years?

Answer 6: The request of \$100 million is not a PR figure. The requested \$100 million represents a balance between our best estimate of what is needed to initiate Pathfinder and the current national budgetary constraints. If Pathfinder is reduced substantially below that level, it will require restructuring and a number of critical areas will be deferred.

Although Pathfinder is not a mission, or even focused on a specific mission, over the first five years of planned activity (FY 1989 to FY 1993), Pathfinder will achieve a total investment of \$840 million in enabling technologies that will make a wide range of future missions possible. Deferring that investment will make those future missions either infeasible or tremendously more expensive. We have the opportunity to make the necessary capital investment now to reduce costs and risks in the future. Pathfinder will provide both an urgently needed foundation of engineering information upon which future national space leadership decisions can be made, as well as starting us down a path that will ensure that the Pathfinder technologies are ready when we need them.

Question 7: What new technological questions still need to be resolved about the various aspects of the program?

Answer 7: Project Pathfinder will allow NASA to develop critical, high-leverage technologies for a broad set of challenging potential NASA missions -- focusing on piloted and robotic exploration of the Solar System. Pathfinder is a technological challenge; our response to that challenge will provide the capabilities and information needed to make those future missions of exploration possible. In that context, numerous important specific research questions and technological challenges will be addressed by Pathfinder.

The capability that Pathfinder will provide will enable exploration of and operations of planetary surfaces. Specific technological questions remain regarding surface and long-duration space environmental effects on a variety of advanced systems. There are also unresolved issues associated with the level of onboard autonomy that can be incorporated into "rovers", "landers" and other spacecraft, given our current limitations in software, sensors, and space-qualified computing power. Finally, how we will process and return to Earth the extremely high quantities of scientific and engineering information that will be produced by advanced missions is a major technological question for planetary surface exploration.

In the area of space transportation, Pathfinder will provide the critical capabilities needed for transportation to, and return from the Moon, Mars, and other planets in the Solar System, as well as for reliable and cost-effective Earth-orbit operations. Technological questions remain regarding how we will implement reusable and space-maintainable systems while retaining the high-performance typically associated with complex, single-use engines. Planetary aerobraking will rely upon an understanding of high-energy and high-enthalpy aerothermodynamics which has not yet been validated as well as adaptive guidance techniques that have not been developed.

Finally, the successful development of systems, large and small, that will enable long-duration human missions is not currently feasible. Long-term effects of microgravity and countermeasures to human adaptation, effects and shielding against radiation, psychosocial and human-machine interfaces -- all of these

represent areas where major questions remain that must be answered if we are to safely and productively send astronauts on extended space missions.

Question 8: Does NASA presently have the resources and facilities to carry out the various aspects of the program? Both development and testing?

Answer 8: NASA currently has the resources and facilities that are needed to move out strongly on Pathfinder implementation. Pathfinder will be implemented as a partnership among the experts at NASA Centers, U.S. industry, and universities. In addition, during the course of the program, it is anticipated that Contractor facilities for development and testing will be utilized or augmented since we will contract out many aspects of the hardware fabrication and testing.

QUESTIONS OF SENATOR PRESSLER AND THE ANSWERS THERETO
Overall Budget

Question 1: The budget request is about \$2.6 billion greater than the FY 1988 appropriation.

How much of this increase is required to continue the ongoing programs and activities, and how much is earmarked for "new starts or activities?

Answer 1: About \$2 billion of the \$2.4 billion increase requested for FY 1989 is for continuing ongoing activities approved by Congress in FY 1988. These activities include completion of the Shuttle recovery efforts and the preparation for resumption of flights, the development of the Space Station, implementation of the mixed fleet of expendable launch vehicles, the launch of several major Space Science missions, replacement of the Tracking and Data Relay Satellite (TDRS) lost in the Challenger accident, development of the second TDRS ground terminal, and continuation of the technology maturation efforts on the National Aerospace Plane. There is approximately \$375 million included for new initiatives and augmentation. The two major development projects included are the Advanced X-ray Astrophysics Facility (AXAF) and the Advanced Solid Rocket Motor (ASRM). AXAF request is \$27 million in FY 1989; ASRM request is \$88 million in FY 1989. The "Pathfinder" technology, an integral part of the President's National Space Policy, will allow NASA to develop critical high leverage technologies for potential future missions to extend human presence beyond Earth orbit into the solar system, is initiated in FY 1989 for \$100 million. Approximately \$60 million is included to augment technology efforts in aeronautics for advanced propulsion, aviation safety and composite activities. Finally, about \$100 million is included for enhanced institutional capability covering additional personnel for Shuttle and a special long range program to modernize the NASA wind tunnels.

Question 2: Where in the FY 1989 budget request do you have the least flexibility -- where is this request the thinnest?

What programs or activities in this request are the most likely to require reprogramming or additional funds due to their technical challenges or due to the operations associated with that activity?

Answer 2: Although the FY 1989 budget request represents a large increase for NASA, the dominant share is required to continue the approved program leaving very little flexibility. FY 1989 will be a challenging year and we have tried to include funding in all program areas to accomplish our program requirements as they are currently known. However, it is too early for us to judge what programs or activities will require reprogramming or additional funds to meet unexpected problems.

Space Station

Question 3: As a result of the FY 1988 appropriations actions, the space station program is undergoing a "rescoping and rescheduling" exercise.

What conclusions, albeit preliminary, have you reached in "rescoping and rescheduling" the Space Station program?

Answer 3: The FY 1988 and FY 1989 budget reductions have caused a slip in the program of approximately one year. The impact of the stretchout on the total cost of the program is under review. However, the stretchout will require sustaining the base support of the program for a longer period, which is likely to raise the total cost. Exact estimates of how much the cost estimate will increase will be available later this year.

Space Station Three-Year Budget Request

Question 4a: This budget request not only calls for \$967 million in FY 1989, but, consistent with the new National Space Policy, requests \$2.1 billion in FY 1990 and \$2.9 billion in FY 1991.

What is the significance of this three-year space station budget request to the program — how would this three-year request affect NASA's ability to address the technical challenges of the program, as well as create efficiencies or savings in the program?

Answer 4a: Maintaining a cost-effective development schedule of the Space Station Program will be impossible without a sustained commitment to the current funding profile. The three-year budget request will contribute to this stability and predictability.

Question 4b: To what extent are the FY 1990 and 1991 budget requests critical to maintaining the current space station deployment schedule?

Answer 4b: Because there are very few program funding reserves early in the program, program flexibility is limited. Any reduction to the requested funding for fiscal years 1989, 1990 and 1991 will have a schedule and cost impact. The severity of the impact depends on the size of the reduction. Thus, the FY 1990 and 1991 budget requests are critical to maintaining the planned Space Station development and assembly schedule.

Space Station Commercialization

Question 5: According to the new National Space Policy, NASA and OMB are expected to "clarify and strengthen the Federal commitment to private sector investment" in the space station program.

What actions do you expect to take to comply with this directive, and what are the most likely hardware elements or operations to be privatized?

Answer 5: The Space Station Program has consistently encouraged private sector participation and involvement in the program both as users and providers. The Space Station Program issued commercial guidelines for commercial participation back in August 1986. Furthermore, the Phase C/D Request for Proposal (RFP) language solicited proposals for Space Station infrastructure-related commercial activities.

To underscore this commitment and as part of the President's Commercial Space Initiatives, NASA will take steps to provide the greatest possible dissemination of the Guidelines including a Statement in the Commerce Business Daily.

These revised Guidelines will include the following elements: (1) a clear statement of policy; (2) criteria for evaluating privatization and commercial proposals; and (3) procedures for submitting and reviewing these proposals. Among the criteria NASA will consider in evaluating proposals are the amount of private sector investment proposed, the degree of risk sharing, cost effectiveness and the proposal's conformity with performance, safety and schedule requirements.

NASA has already solicited and received proposals for commercial involvement in the development of the approved Phase I Space Station. These proposals will be carefully considered. NASA will give positive consideration to proposals to accelerate private sector investment in Space Station development and operations in the form of either goods or services not already contracted for. Areas which appear especially suitable for commercialization include:

- o Logistics services;
 - fluid resupply
 - waste disposal
 - produce changeout and return
- o Logistics vehicles and carriers;
- o Payload checkout facilities and services;
- o Man-tended free flying laboratories;
- o Orbital storage facilities;
- o Co-orbiting experiment and applications platforms;
- o Repair, calibration and test facilities; and/or services.

Where private sector investment capabilities are insufficient, joint Government-industry ventures could also be considered. In all cases, the commercial partner would own all rights to resulting technologies, with royalty-free use by the Government for its own purposes

We anticipate that these actions will help encourage private-sector participation in the Space Station program. To the greatest extent possible, NASA will facilitate and encourage the private sector to develop specific Space Station concepts.

In addition, NASA will seek to rely on private sector design, financing, construction, and operation of future Space Station requirements, including those currently under study.

Consistent with the National Space Policy, NASA should purchase commercially available space goods and services to the fullest extent possible. NASA should not conduct activities with potential commercial applications that preclude or deter commercial sector space activities except for National security or public safety reasons.

Space Station Crew Escape Rescue Vehicle

Question 6: How much in the FY 1989 budget request is committed to a space station crew escape rescue vehicle (CERV), and what have we learned to date on developing such a capability?

Answer 6: FY 1987 - \$3 million; FY 1988 - \$4 million; and FY 1989 - \$11 million

We are in a concept definition phase. We have established the feasibility of a station-based return vehicle option. Responsibility has been transferred to the Office of Space Flight. Adm. Truly will make recommendations in a few weeks.

Question 7a: What are the options under consideration for this crew escape rescue vehicle capability, and what are the relative costs associated with each?

Answer 7a: The primary design reference missions involve a grounded NSTS, a Space Station emergency, and a medical emergency. The ongoing in-house studies and planned system definition efforts will identify the capabilities required to satisfy these design reference missions. Generally crew return capabilities will include de-orbit propulsion and controlled descent and landing in a safe manner.

We are in a concept definition phase and have established the feasibility of a station-based return vehicle option. The scope of the studies has been expanded to encompass an "Assured Crew Return Capability" (ACRC) including the following options:

- o A new ground- or space-based emergency return vehicle
- o An orbiter, modified as necessary, for extended on-orbit stay time
- o A ground-based, capable shuttle launch on need capability
- o Unmanned shuttle launch with automated or remotely controlled rendezvous/prox ops to provide reentry-capable orbiter to space station crew
- o ELV's, in conjunction with OMV, to resupply space station crew for indefinite period
- o Review possible modifications to station safe haven approach which may enhance other options.

It has not been determined that the Space Station requires this capability. Further, NASA will seek to rely, to the greatest extent possible on private sector design, financing, construction, and operation of future Space Station requirements, including those currently under study.

Question 7b: What are the major considerations that must be taken into account in deciding upon this capability?

- Answer 7b:
- 1) Space Station Requirements
 - 2) Cost and schedules
 - 3) Definition of emergency design reference missions
 - 4) Reentry g forces

- 5) Degree of crew involvement in reentry and landing
- 6) Space based vs. ground based options
- 7) Private sector investment and involvement

Question 8: At what point in the space station assembly process should a crew escape rescue vehicle be available, and when must a decision be made on a particular option in order for it to be available at that time?

Answer 8: Generally, we have been studying the requirements for an assured crew return capability by the date of a planned permanent manned presence at the space station. In-house Phase A efforts are underway. We plan a combined in-house/industry Phase B (systems definition) effort beginning in FY 1988 and extending through FY 1989. We have not made a decision, however, that a CERV is required for the Space Station.

Space Station Polar Platform

Question 9: If no Shuttle capability is available from the West Coast, you will, as I understand, have to service the polar platform using telerobotics.

Could you describe the scenario of a telerobotic servicing mission of the polar platform, and will these telerobotic capabilities be sufficiently developed to enable such a mission when it is required?

Answer 9: NASA is currently studying methods for providing automated servicing of the Polar Platform. In particular, NASA is looking at the technological feasibility of telerobotics and ELV-based servicing; that is, of using ELV's to transport new experiments to the platform. Telerobotics, either based on the transportation system or on the platform itself, would perform the change out and maintenance of selected platform experiments. It is important to keep in mind, however, that the costs of providing this kind of telerobotic servicing must be balanced against the cost of providing additional platforms when old ones become obsolete.

Question 10: How much do you expect the polar platform instruments to cost, and will NASA alone be responsible for these costs.

Answer 10: The costs for the instruments for the NASA Polar Platform are estimated to be as follows:

NASA instruments	\$410 million
NOAA instruments	205 million
Japanese instruments	250 million
French instruments	10 million
U.K. instrument	5 million
Canadian instrument	5 million

TOTAL	\$887 million
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The costs of the instruments to fly on the European Space Agency (ESA) polar platform are as follows:

NASA instrument	\$ 60 million
NOAA instruments	32 million
European Operational instr.	19 million
ESA instruments	430 million
TOTAL	\$541 million

Note that this does not include the costs of certain other elements in the payload such as the direct broadcast system for operational downlink of data. These figures also do not include the cost of the servicing or replacement copies of the instruments required for the fifteen year mission life of Eos and the continuation of the operational payload. These U.S. instruments are still in the planning phase and will have to compete against other NASA needs prior to a formal new start.

Space Station Transportation

Question 11: NASA's January 1988 report to the Congress on space transportation for the space station concludes that there are down-mass limitations in the use of existing expendable launch vehicles.

Nevertheless, do you intend to incorporate into your planning an alternative space station transportation capability? If not, do you intend to rely solely on the Shuttle?

Answer 11: The current Space Station baseline requires the use of five (5) Shuttle flights per year for steady-state operations. While unmanned launch vehicles are not required for either assembly or operations, they could lead to a reduced reliance on the Space Shuttle during the operational period. The Space Station program, with the Office of Space Flight, is conducting a detailed study of how unmanned launch vehicles could be accommodated, including a definition of appropriate interface and safety requirements. Thus, STS will always be "baseline" present, other options are being seriously considered for use during the operational period.

Space Station Program Support Contract

Question 12: Do you feel that NASA and its contractors, particularly the contractor managing the Program Support Contract, are adequately staffed to support the space station program?

Answer 12: Due to budget constraints, the Space Station contractor staff levels are currently frozen at a level that allows only the absolute minimum level of activities consistent with a First Element Launch in the first quarter of 1995.

Question 12a: How many people does NASA presently have committed to the space station program, and how do you expect this number to grow?

Answer 12a: The current number of civil servants supporting the program is approximately 2100. This number will increase to approximately 3000 per year at program peak (1992-1994).

Question 12b: Similarly, how many people are presently committed to the Program Support Contract, and how do you expect this number to grow?

Answer 12b: As of February 29, 1988, there were 475 people on the PSC contract. This number will grow to approximately 1260 Full Time Equivalents (FTE's) per year during the contract's peak years (FY 1992 thru FY 1995).

Industrial Space Facility

Question 13: How much will NASA charge to launch the CDSF-- will NASA charge the full cost of a Shuttle launch? If not why?

Answer 13: The RFP instructs the CDSF offerors to propose using a base price for a Shuttle launch of \$110 million in 1988 dollars. This price represents the additive costs of flying the Shuttle and essentially continues the previous pricing policy. In conformance with the President's space policy, a new Shuttle pricing policy for future commercial users is under development and will be issued later this year.

Question 14: To what extent are termination liability and indemnification against third-party claims arising from a launch accident critical to the economic viability of a CDSF?

What is the Administration doing to address these two issues?

Answer 14: Termination liability and indemnification are both items identified by potential bidders as of significant importance. In recognition of their concern, NASA, on behalf of the government, has drafted language requesting an addition to the FY 1989 NASA authorization bill to provide for the payment for contingent liability of the government which may accrue should the government decide to terminate for its convenience. The payments would be limited to the amounts provided in advance in appropriations acts. The considerations for third-party indemnification by the government for CDSF has been reviewed and the policy decision is that the same provision provided for the ELV'S will apply, i.e., there will be no third-party indemnification by the government.

The Administration has proposed legislation to Congress to provide a \$200,000 cap on non-economic damage awards to individual third parties resulting from commercial launch accidents.

Question 15: How much would NASA have to spend to develop the instruments and hardware to use the CDSF over this five-year period?

Answer 15: The benefits of using this facility results from its complimentary relationship to Space Station. For example, new experiments or processes in microgravity requiring on-orbit trials and design, and process refinements prior to long-term commitment on Space Station, will be manifested resulting in operations savings and long-term research efficiency.

On the other side of the coin, are the uses of the CDSF to verify production microgravity processes that have been developed and matured on the Space Station. These would be accomplished primarily in the free-flying mode. The \$400 to \$700 million is the projected lease cost for the five-year period for all government users. NASA will use some portion of that total leased capability.

The experiments identified as candidates for CDSF are derivatives of existing experiments or derivatives of systems targeted for future Spacelab or Space Station development. Depending on the final capabilities of the CDSF and the share of the volume and related resources allocated to NASA, the range could be from \$10 million up. In the FY 1989 Presidents request, \$25 million is proposed to be used for experiments on the CDSF.

Question 16: What is the maximum possible commitment for which NASA will be responsible if it leases a CDSF and outfits it with instruments and experiments?

Answer 16: The elements of cost to the government is projected to be \$400 to \$700 million for the five-year lease period of which NASA would be responsible for its share as one of the government users. The government agency use shares have not yet been determined. There would be a payload development cost of the magnitude ranging from \$10 million. In addition, there would be a relatively small civil service cost to the government for the lease management.

Question 16a: If a contractor is selected to develop a CDSF, when would NASA be expected to begin making lease payments and other related expenditures?

Answer 16a: NASA, on behalf of the government, would begin making lease payments when a launch ready CDSF is available at the launch site.

Question 17: What could this CDSF provide that Shuttle-Spacelab missions and an Extended Duration Orbiter could not provide, or would this CDSF provide a capability so unique that lease payments of this magnitude would be justified?

Answer 17: There are at least two significant features of the CDSF compared to the Shuttle-Spacelab missions, and the Extended Duration Orbiter (EDO). The CDSF will provide a much longer period of microgravity for research (4 to 6 months as compared to 7 to 10 days for the current orbiter; of 16 to 20 days for the Extended Duration Orbiter). In addition, the CDSF, in the free-flying mode, will provide a low gravity that is one to two orders of magnitude lower than the Spacelab levels. In the attached mode, greater power for experiments will be available than Spacelab.

Question 18: How important is the development and use of a CDSF to space commercialization?

Answer 18: The CDSF contributes to the President's commercialization initiatives by providing a facility to be used in commercial research, product development and production. It is expected to be the forerunner of a space based commercial infrastructure. It should offer early opportunity to develop, not just the technical aspects of such an operation, but also new and innovative government industry relationships and processes required for this new commercial frontier of microgravity manufacturing and production.

Advanced Solid Rocket Motor (ASRM)

Question 19: Of the \$88 million requested for the Advanced Solid Rocket Motor program, I understand that \$27 million is earmarked for the study of a Government-Owned, Contractor-Operated (GOCO) solid rocket motor facility, to be constructed by NASA.

How specifically will this \$27 million be used?

To what extent is this consistent with the Administration's policy towards utilizing the private sector?

What priority is NASA placing on the funds now earmarked for the study of a proposed GOCO facility?

Answer 19: The \$27 million requested for FY 1989 is not intended for studies, but is needed for the final facility design effort and for the site preparation (e.g., clearing of lands, cutting roads, etc). Since the facility construction paces the ASRM development program, implementation of the effort is critical to the program (and the eventual cost thereof). The funding would be required for either a GOCO facility or a contractor facility wherein the work was a direct charge to the Government; all or part of the funding would be required under the Baker Amendment for termination liability if the facility were contractor financed (with subsequent depreciation or amortization).

All of the work (design, construction, and operation of the facility and ASRM development and production) is to be done by the competitively selected contractor from the private sector; therefore, the Government is not competing with the private sector. Furthermore, in keeping with the Administration's new Space Policy, NASA intends to solicit proposals from industry for private financing of the facility and for a GOCO facility. Final selection of the facilitization approach will consider the total cost to the Government and the ability of the Government to recompete the contract.

The \$27 million requested for FY 1989 is requisite to the ASRM program implementation and preservation of procurement options, including commercialization

Question 20: There has been considerable discussion about the need to modernize solid rocket motor manufacturing facilities.

What is your view of the type of modernized facilities that are needed?

Are there private contractors willing to make investment necessary to satisfy the modernization requirements deemed essential?

Answer 20: Without disclosing information that might be prejudicial to the competitive procurement, the modernization of the facility is expected to eliminate many of the currently labor intensive operations through the use of automation and robotic techniques that are widely employed in other industries; to include designs for control of cleanliness and environmental conditions for critical operations; to permit stringent, repetitive controls for processes such as case preparation, propellant loading, and nondestructive evaluation (NDE) and, to incorporate production planning and control measures as are used in other industries.

As private sector financing of the production facility is part of the ASRM procurement process, we will determine whether the private sector is willing to make necessary investments to modernize facilities. The private sector may also offer to make the investment to modernize existing facilities to meet the requirements for the ASRM program.

Question 21: What is the total development cost of an ASRM program and how long would it take to develop this capability?

Answer 21: The total development cost, including the prime contractor effort and the associated NASA costs for Shuttle system support and integration, operation of Government test facilities, launch site accommodations, and program support, is estimated at just under \$1 billion in real year dollars. In addition, the construction of the production and test facility, whether government or contractor financed, will cost \$200 to \$300 million, exclusive of the tooling and plan equipment which is included in the aforementioned \$1 billion.

To develop and verify the ASRM is expected to take approximately five years, leading to flight in 1994 (assuming contract initiation in early 1989). The facility construction is paced largely by the funding levels; for the anticipated funding rate, the production and test facility (which actually entails many buildings and installations) will be completed in about four years. With a higher rate of funding, whether CoF or privately financed, the time might be reduced by about a year.

Question 22: There is considerable discussion about whether the ASRM program should be conducted in a Government-owned, contractor-operated (GOCO) facility, as opposed to a contractor-owned, contractor-operated facility (COCO).

Answer 22: The majority of the Phase B contractors recommended a GOCO facility because of:

- An apparent lower total cost to the Government (no return on investment, taxes, insurance, etc.).

- Availability of existing Government-owned real estate. Four of the five contractors indicated that their currently owned facilities were not available and/or suitable for the ASRM effort.

- Competitive procurement equalization throughout the industry, predicated on the preceding observation.

- Ease of acquiring construction permits.

- Flexibility for the Government in terms of facility utilization (e.g., for future program competitions), maintenance of a state-of-the-art capability, growth potential in terms of production rate and design or process changes, and recompetition potential for the ASRM contract. Because of the magnitude of the ASRM facility investment and the uniqueness of the facility, it would not be practical to create alternate sources for the ASRM within the private sector; thus, whoever controls the facility also controls the future of the ASRM Project (and, hence, the Shuttle Program). The ability to recompet the ASRM contract is fundamental to the protection of the Government's interests in maintaining a high level of competence and reasonable cost; this can be best realized by a GOCO facility. Furthermore, the facility should be considered a National asset.

- Avoidance of disruption to a contractor's existing operations if an existing facility were to be modified.

The advantages of a contractor-owned facility include:

- A lower initial funding requirement if the facility were capitalized, even though the ultimate cost to the Government might be considerably greater.

- A shorter construction period if the contractor were able to provide a higher funding rate.

- Ability to utilize some existing equipment and infrastructure if it were possible to expand an existing plant. This might also permit use of an existing work force without relocation.

- Possible avoidance of the Government having an excess facility were there no further need for large solid rocket motors.

Question 23: What would it cost NASA to develop its own solid rocket motor facility, and would those costs be shared by any other agency or by the contractor?

Answer 23: NASA will bear the full cost for facility construction regardless of whether it is Government-owned or contractor-owned. That cost, in either case, will be \$200-300 million for construction of the facilities, plus another approximately \$250 million for equipping that facility.

It is not expected that other agencies would share the facilitization cost; however, as a national asset, the production and test capability may well be attractive to other agencies for future use.

Contractors may be willing to capitalize the facility, with the requirement for recovery of that investment plus a return on investment.

The facility costs, be they GOCO or contractor-financed or owned, have been developed by the Phase B contractors.

Question 24: What precedent is there for establishing a GOCO for a civil space program.

Under what circumstances is a GOCO generally deemed to be preferable to a COCO?

Answer 24: Prime examples of GOCO facilities used in the civilian space program are the Jet Propulsion Laboratory, the Michoud Assembly Facility for the Shuttle External Tank production, a wide variety of test complexes at the National Space Technology Laboratories, Johnson Space Center, Marshall Space Flight Center, and Arnold Engineering Development Center, the Slidell Computer Complex, and the Shuttle Solid Rocket Booster Assembly and Refurbishment Facility. The proposed ASRM facility is by no means precedent setting.

A GOCO facility is attractive, and preferable, to a contractor facility when the requirement is so speculative or hazardous that private capital is not available at a reasonable cost, when there is no potential commercial market and the Government's interest are tentative, when National security is paramount, or, as is the case for the ASRM facility, when a contractor-owned facility would jeopardize the Government's ability to ensure technical competence or realistic costs due to one firm having a monopoly on the business.

Question 25: Which approach -- a GOCO or COCO -- would benefit most our civil space program, and why?

Answer 25: It is our belief that a GOCO facility best satisfies the civilian space program requirements and goals with respect to maintaining a highly competitive environment within the solid rocket motor industry, minimizing the total cost to the Government and ensuring that facilities are maintained at a technological level consistent with the needs for safety and reliability. It is our belief that a COCO facility, while meeting the immediate technical requirements, would force the Government's dependency on the selected contractor for not only the duration of the Shuttle Program, but for any other future requirement for solid rocket motors by effectively eliminating any future industry competition. The Government's ability to recompute the ASRM contract and/or compete future contracts is vital to the civilian space program.

Advanced X-Ray Astrophysics Facility (AXAF)

Question 26: What are the greatest technical challenges in the Advanced X-Ray Astrophysics Facility (AXAF) program, and how will the program be managed to avoid excessive cost overruns?

Answer 26: The High Resolution Mirror Assembly is the most technologically challenging and critical element in the AXAF development program. Although this system is a direct derivative of that flown on HEAO-2, its greater size and increased figuring and polishing requirements, coupled with its being on the critical path of the AXAF schedule for the first four years of the program, drove NASA to pay special attention to this system.

NASA has already successfully completed a prototype AXAF mirror assembly. As a further protection against program growth, NASA has planned a development program for AXAF in which critical events in the mirror assembly occur at carefully selected points in the AXAF spacecraft development program. This approach permits management of the buildup in other areas of the program so that the impact of any unlikely residual technical problems can be minimized.

Question 27: What are the expected annual operating and maintenance costs for AXAF, and what is the expected life of the satellite?

What are the expected servicing and reboosting requirements for AXAF?

Answer 27: The average annual costs for operating and servicing AXAF are estimated to be \$79 million in current FY 1988 dollars. This inflates to \$104 million, at 3.5 percent GNP, in 1997 which is the first full operational year for AXAF. This funding supports all science operations, data analysis by the scientific community, new scientific instruments, servicing and replacement of orbital replacement units, and orbital maintenance. The observatory is being designed to have a 15 year operational lifetime.

AXAF is expected to require three or four servicing missions during its lifetime. These missions would be used to upgrade the scientific instruments, to replace subsystems that are expected to wear out as well as those that have degraded or failed unexpectedly, to resupply expendables, and to reboost the observatory altitude.

Question 28: How and to what extent is the AXAF program accommodated within the Office of Space Science and Applications (OSSA) budget over the next three to five years—does the OSSA budget experience adequate growth to accommodate AXAF, or does it remain essentially level?

What role, if any, does the AXAF program have in terms of U.S. space leadership?

Answer 28: AXAF fits in a level budget for space science and applications in fiscal year 1990 and the subsequent fiscal years.

The world astrophysics community recognizes that AXAF is vastly more powerful than any other mission that either has flown or is in planning today. For this reason, AXAF has long been viewed as the centerpiece around which other nations and agencies have planned their own programs. For example, ESA's mission "XMM" will conduct follow-up spectroscopic studies on bright X-ray sources, while AXAF will do "discovery" science, finding new sources and new classes of objects, beyond the limits of any planned mission today. No other

nation can build an X-ray telescope with a 1/2 arc second angular resolution. With its vastly greater scientific potential, AXAF will provide world leadership in this important and exciting field, as well as providing a capability for guest investigator use by the entire world astrophysics community that will exceed any other planned mission.

Question 29: To what extent is funding for AXAF in FYs 1989 and 1990 designed to solve the most challenging technology problems?

Answer 29: The AXAF funding in FY 1989 and 1990 is going to three primary areas: the mirror system development; the science instrument development; and to observatory systems engineering. The most technologically challenging problem on AXAF is the development of the AXAF mirrors, and this will get 70 percent of the first two years' funding. The second technical challenge on AXAF is the development of the science instruments and they will get 23 percent of the funds. The systems engineering activity which is required to review requirements and to ensure that everything "fits together" will get the remaining funds.

Question 30: What are our foreign competitors, ostensibly the Soviet Union, Japan, and the European Space Agency, doing with respect to future x-ray astronomy missions or observatories?

Answer 30: Other nations, particularly Germany, Japan and the Soviet Union have continued their efforts, but along lines complementary to AXAF. Germany, with the ROSAT mission, has chosen to concentrate on very long wavelength (44 to 6 angstroms) x-rays and extreme ultraviolet radiation. Japan has flown three modest scale missions with highly specialized capabilities not at all competitive with AXAF. Japan's next x-ray astronomy mission, "Astro-D" (1993), will be a small, 1-2 arc minute resolution instrument (a factor 100 poorer than AXAF) for specialized spectral studies. The Soviet Union has produced little of scientific value from the astrophysics "Kvant" module on the MIR space station to date; however, the U.S.S.R. has ambitious plans for further missions, including GRANAT (1988) and Spectra-X (1994?). These will not rival AXAF since no instrument planned for these missions approaches the angular resolution (by a factor of 50) or the spectroscopic capability of AXAF. The European Space Agency (ESA) plans a mission known as X-ray Multi-Mirror Mission (XMM) for launch about 1998, which will accomplish moderate angular resolution, "high-throughput" spectroscopy. This mission will be limited to spectroscopic studies of the brighter X-ray sources.

Future Launch Systems

Question 31: What is NASA's current thinking on the need for a Shuttle-C capability -- what requirements have been identified for such a capability, and what new missions or needs would likely be identified if such a capability existed?

Answer 31: If Shuttle-C were available, we would use it for station assembly. Other potential missions include planetary and assured access for Titan/Centaur class national security. However, there are no NASA missions currently approved that require the heavy-lift capabilities of a Shuttle-C.

Question 32: When would be the optimum time for a Shuttle-C to be available, and what would be the approximate development costs and recurring costs?

Answer 32: The projected development costs is \$1.5 billion. Recurring costs are projected to be between \$250 million and \$300 million per flight. Decision on development of heavy-lift capabilities will depend on future approval of firm national requirements. No additional funds will be expended or requested for Shuttle-C unless and until the Administration determines that an approved heavy-lift program requires Shuttle-C. The Appropriations have withheld funds appropriated for NASA and DOD for Advanced Launch Systems (ALS) studies, pending the receipt of a satisfactory report on the ALS program.

Question 33: Does NASA have any requirements for an ALS in the late 1990s, and, if not, what are some likely NASA uses of such a capability?

Answer 33: There are no NASA missions currently approved that would require the heavy-lift capabilities offered by ALS with the Shuttle-C concept as part of the ALS. There may be future missions that could benefit from such a capability, but the scope and timing of these potential missions are unknown at this time.

Question 33a: In what ways would an ALS duplicate the capabilities of a Shuttle-C, and, conversely, how would ALS capabilities distinguish themselves from those of a Shuttle-C?

Answer 33a: The Shuttle-C studies are part of the overall ALS activity. The studies look at different approaches to provide a heavy-lift capability, different availability dates, different launch rates, derived systems vs. new systems. Decisions on the needed heavy-lift capabilities will depend upon future approval of firm national requirements.

Question 34: Has the ALS program evolved from a vehicle development program to one of technology development? If so, why, and what are the implications for this change in character of the program?

Answer 34: Decisions on development of heavy-lift capability will depend upon future approval of firm national requirements.

Question 35: What are expected costs of the ALS program, both for the DOD and for NASA? Would these costs be just for technology development, or would they apply to the development of a vehicle?

Answer 35: Costs for ALS will be highly dependent on the concept selected; as a final configuration for ALS has not been selected, it would be premature to speculate on specific costs. The ALS plans include concept definition studies and systems definition studies combined with a focused technology program. \$225 million is available pending release for FY 1987/1988. Funding planned in FY 1989 through FY 1992 is approximately \$200 million per year. This funding profile does not reflect a full scale system development.

Project Pathfinder

Question 36a: Based on the plans of the Pathfinder program, when will we be in a position to decide on a future space leadership initiative, such as the Mission to Planet Earth, or a return to the Moon, or manned or robotic missions to Mars?

Answer 36a: The technology programs which comprise Pathfinder will support a national decision regarding future U.S. space leadership initiatives. The timeframe, for this decision will depend on the progress made in the Pathfinder program as well as fiscal and other considerations.

Question 36b: What are the most important factors that must be considered in making a decision on a future space leadership initiative?

Is there a logical sequence to consider in making this decision - in other words, would it make sense to initiate first the Mission to Planet Earth before returning to the Moon or going to Mars, or similarly, should we first return to the Moon before attempting manned or robotic missions to Mars?

Answer 36b: The most important factors to consider in making a decision on future space initiatives are the technological underpinnings that are required to make any potential program both feasible and cost-effective, and the detailed scenarios that make the most sense for a particular initiative.

At the present time, there is no established logical sequence from one potential initiative to another. However, there is a logical, broadly-based requirement for the development of critical, high-leverage technologies prior to decisions on any particular missions--Project Pathfinder meets that requirement.

Question 37: What will be standards against which Pathfinder will be measured--what will be the standards of success?

Answer 37: The ultimate standard will be the readiness of technology at the time a mission requires it. In the near term, Pathfinder will be designed to support a national decision regarding future ambitious space missions. The 17 element programs that make up Pathfinder are being defined with specific, significant technical objectives.

Tracking and Data Relay Satellite System (TDRSS)

Question 38: I understand that TDRS-3 and TDRS-4 satellites are scheduled for launch on, respectively, the first and fourth Shuttle launches once Shuttle missions resume.

How flexible is the launch sequence of both of these satellites, within the context of the overall Shuttle manifest--is there "hard" requirement that they maintain those launch dates?

Answer 38: Our current internal plan has TDRS-3 and -4 scheduled on the first and third shuttle launches. It is necessary

to provide a stable on-orbit satellite constellation that users such as the Hubble Space Telescope can depend upon in the future.

Question 39: Under what circumstances would the launch dates of TDRS-3 and TDRS-4 be delayed?

Answer 39: Launch dates for these two spacecraft are dependent upon the Shuttle schedule and there are no plans to delay either launch.

Question 40: How much does the FY 1989 budget request provide for the development of TDRS-7, and when will it be available for launch?

Answer 40: The FY 1989 budget request is \$79 million for TDRS-7. It is projected to be available for launch in mid-1992.

Question 41: What is the health of TDRS-1, and when is it expected to expire? How quickly can a replacement for TDRS-1 be launched once TDRS-1 expires?

Answer 41: Current status of TDRS-1: Degradation has affected our ability to control the TDRS spacecraft and our ability to transmit signals to user spacecraft. Most of this degradation has been a loss redundancy. One should remember that TDRS-1 will have used 5 of its 7 year design life in April 1988. There have been five key failures which include: service failures involving K- and S-Band; System failures including thrusters, antenna pointing, spacecraft system interruptions due to geosynchronous environment. All follow-up spacecraft have been modified to correct these problems.

TDRS-3 and -4 will be launched as quickly as possible. It is planned to replace TDRS-1 with TDRS-5 in 1990.

Long Duration Exposure Facility

Question 42: With the Long Duration Exposure Facility (LDEF) decaying from orbit faster than originally predicted, what options is NASA considering to retrieve the satellite? How will this affect the Shuttle manifest?

Answer 42: NASA places high value on the scientific worth of the LDEF experiments and has made the proper adjustments in the Shuttle manifest to recover the LDEF intact. In the recent March 1988 manifest, NASA has manifested the retrieval of the LDEF satellite for Shuttle flight #32, scheduled for July 1989.

Question 43: What would be the likely result if NASA were unable to retrieve LDEF -- where would it land and what damage, if any, could it possibly cause?

Answer 43: Since solar activity cannot be precisely predicted at this time, we only know the range (between Spring through Fall of 1990) of reentry. Hence, we cannot predict where the reentry would occur and any potential damage from debris. We do expect that solid pieces would strike the Earth.

Question 44: How have the LDEF experiments been affected by the additional three years in orbit?

Answer 44: Based on our knowledge of the different experimental objectives of the payload, we estimate that about one-third of the 57 experiments on the satellite will be enhanced in value by the longer exposure, one-third will retain its original value, and the remaining third will be damaged to varying degrees.

I will have to get the Aero people to telexmail their material -- it's in a different word processing language and I can't send it over my machine with my current software.

Question 45: Since 1969, the U.S. share of the world jet transport market has slipped from 91 percent in 1969 to 65 percent in 1987.

While I recognize that part of this decline in market share is attributable to non-technology factors, to what extent is this decline attributable to a narrowing of the gap in aeronautical technology?

In what aeronautical technologies have we maintained a considerable competitive margin, and in what technologies have our competitors caught or surpassed us?

Answer 45: Traditionally, the U.S. civil transport manufacturers have led the world in the development of technically superior transport aircraft. Nearly 90 percent of the free world airline fleets of 7,000 jet transport aircraft were made in the U.S. This position still remains strong and, at the end of 1987, the backlog of firm orders for U.S. civil jet transports reached a record level of 822 aircraft worth \$32 billion. Of this total, \$12 billion were orders by U.S. customers and \$20 billion were foreign customers. This position of U.S. leadership in the world market for technically superior transport aircraft is also reflected in the positive contribution of \$15 billion by our aerospace industry to the balance of trade in 1987.

Technology has always been a primary factor in the competition for transport aircraft. History illustrates very clearly that those aircraft that are technically superior control the market. The Boeing 247 was replaced by the DC-3 that was in turn replaced by successively larger piston-engined transports. The piston-engined transports were replaced with jet transports, with a succession of technically superior aircraft, from the Comet to the B-707 and DC-8, followed by the B-727, DC-9, B-737, B-747, DC-10, L-1011, B-757, B-767 and new models of the MD-80, B-737, and B-747.

Foreign manufacturers, however, most notably the Airbus Consortium, have also recognized the importance of technological superiority and have quickly applied technology improvements in their newer aircraft models, from the A-300, to the A-310, and the A-320. In fact, the A-320 incorporates more advanced technology than current U.S. transport aircraft that are competing for the same market. This is certainly a powerful competitive factor and has contributed to its success in the marketplace, with more orders on rollout than any other civil transport.

Currently, the U.S. has maintained a strong competitive margin in propulsion, with U.S. engines from Pratt & Whitney and General Electric remaining the dominant engine choice on new transport aircraft. The U.S. also has the technology lead in the development of the advanced turboprop propulsion systems that are the leading candidates for new short-medium range transport aircraft such as the B-7J7 and MD-91.

With the A-320, our foreign competitors have shown that they have developed impressive technology advances in aerodynamics, composite structures, and control systems technology. Maintaining the lead in developing technically superior transport aircraft requires a continued national commitment to aggressive technology development and validation. Combined efforts by the effective partnership of the U.S. industry and NASA aeronautics research capability are required to maintain future technical superiority.

Question 46: How and to what extent does this FY 1989 budget request for Aeronautics Research and Technology respond to this aeronautical technology challenge?

Answer 46: The NASA FY 1989 Aeronautics R&D budget request includes aeronautics R&T increases in composites, advanced propulsion, and aviation safety/automation. These augmentations, combined with changes in focus within the ongoing program, are designed to respond to the aeronautical challenge. In addition, NASA is currently working with the industry to define the long-term civil aeronautics technology development and validation requirements for maintaining U.S. leadership into the 21st century.

Question 47: In February 1987, the White House Office of Science and Technology Policy published an eight-point action plan to achieve the previously-established National Aeronautical R&D Goals in subsonic, supersonic, and transatmospheric flight regimes.

What progress has been made in the past year in implementing this eight-point action plan?

What milestones remain in implementing this plan, and what will be the standards for success for this plan?

Answer 47: The requested budget augmentations in FY 1989, combined with a refocusing of efforts in the ongoing program, are in concert with the eight-point action plan and will intensify the NASA efforts directed at the plan. Specifically, NASA is continuing its efforts directed at providing the enabling technology for the National Aero-Space Plane program, working with industry to determine the most promising technical concepts and necessary technology developments for future high-speed civil transports, increasing cooperative research efforts, strengthening its university programs, and working with the FAA to develop the technology to enhance the safety and capacity of the National Airspace System.

The FY 1989 augmentations will increase the R&T on innovative composite structures, including manufacturability; advanced propulsion concepts; and aviation safety/automation. In addition, the 5-year Wind Tunnel Revitalization program, included in NASA's Construction of Facilities budget request will rehabilitate and modernize these critical national facilities.

Advanced Communications Technology Satellite (ACTS)

Question 48: Once again, the Administration has failed to include funding in the NASA budget request for the Advanced Communications Technology Satellite (ACTS) program. Yet, NASA has a commitment from the Appropriations Committees to fund the program up to a cap of \$499 million, along with an agreement by RCA to complete the program within the constraints of this cap.

Do you have complete confidence that RCA will have a completed satellite by 1992?

Answer 48: The restructured program allows GE (RCA) more than four years to complete the spacecraft. This is normally adequate to initiate and complete most communications satellite systems. Given that a considerable amount of work on ACTS has been already accomplished, we fully expect the ACTS to be completed on time. Furthermore, the GE contract will be managed using a performance measuring system (PMS) to closely monitor monthly schedule and cost variances.

Question 49: If RCA at some point states that it cannot complete the program on schedule within the cap of \$499 million, what are NASA's options?

Answer 49: We acknowledge that there is a financial risk to the contractor to complete ACTS within the cap. However, the contractor recognizes that there is a potential gain in future marketing of this technology to the commercial communications satellite industry and accordingly has expressed willingness to use its resources to limit the government's exposure to the stated cap. This willingness to invest in this technology is precisely why the Administration has continually tried to avoid competing with the private sector in the development of this technology and ensure that it be responsive to market needs. For our part, we will work closely with GE and will judiciously grant them specification relief in those areas where the technological integrity of ACTS is not compromised.

Extended Duration Orbiter (EDO)

Question 50: The FY 1988 appropriations action directs NASA to commit \$5 million for activities leading to an Extended Duration Orbiter (EDO).

How much is in the FY 1988 budget request for an EDO, what is the total cost to complete this EDO development, and when would this capability be available for use?

Answer 50: The FY 1989 budget request for EDO is \$10 million. The EDO total development is \$125 million and will be available 45 months after authority to proceed (ATP). The ATP date is a function of whether the development is done by an existing prime contractor or a competitive procurement is required. This will be determined in April.

Question 51: How many missions per year would you envision for an EDO, and what would be the maximum mission duration that an EDO would enable?

Answer 51: We would envision two flights per year that would use the EDO capability. The maximum duration in our current plans as currently budgeted is for sixteen (16) days.

Question 52: How could an EDO be used in conjunction with Shuttle/Spacelab missions and with a commercially developed space facility?

Would an EDO capability offer any advantages in terms of its use with the space station?

Answer 52: The EDO would extend the stay-time of a Spacelab mission to 16 days, and allow the scientific community to obtain almost three times the amount of "experimentation" time over a seven-day mission. For commercially developed facilities (unmanned), additional time would be utilized to off-load products and consumables, and effect equipment changeout and repair.

The EDO would prove very useful to protect against contingencies during crew changeout and station resupply. If Space Station was constructed by putting construction material in orbit using ELV's, the EDO would be used to assemble larger portions of the station on each flight. Otherwise, the reduction in Payload Bay Volume offsets the value of the increasing the on-orbit time.

Use of External Tanks by Private Sector

The National Space Policy states that for five years the expended Shuttle External Tanks will be available at no cost to all feasible U.S. commercial and nonprofit endeavors for research and storage.

Question 53a: What is the definition of "feasible" in the context of this policy statement?

Answer 53a: Any viable space application such as: 1) a university sponsored Gamma Ray Imaging Telescope, 2) commercial manufacturing in space, 3) research in space and/or 4) space habitability offered by any recognized commercial research organization and/or non profit group.

Question 53b: What hardware or propulsion changes will NASA have to make to keep the expended External Tanks in an orbit that the commercial or nonprofit endeavors can claim the Tanks?

Answer 53b: Guidance, propulsion and RCS will have to be added to ensure a stable orbit at the inclination and altitude desired for the particular operation.

Question 53c: Who will bear the costs associated with making these changes?

Answer 53c: The cost of all associated changes will have to be borne by the user.

Question 53d: What guarantees will the commercial and nonprofit endeavors be expected to make concerning the safety of the External Tanks?

Answer 53d: The user will have to ensure that the ET meets the STS standards and in addition the ET will have to be fitted with a deorbit control system to ensure that deorbit occurs in remote areas.

Competitiveness of U.S. Space Program

Question 54: The report prepared for you on Space Leadership Initiatives, concludes that "the U.S. has clearly lost leadership in" the "exploration of Mars" and "in long-term habitation of low Earth orbit." The report goes on to say that the U.S. "is in danger of being surpassed in many other areas during the next several years."

Do you agree with this assessment? How do we regain the leadership in these areas, or should we be willing to concede leadership in these or other areas?

Answer 54: The President's Space Policy states that a fundamental objective of U.S. space activities continues to be space leadership. It also acknowledges that such leadership in the increasing competitive international environment does not require U.S. preeminence in all areas of space activities. In the area of Mars exploration, the U.S.S.R. currently plans three missions to Mars in the early 1990s with a sample return mission planned for later in the decade. The United States currently has one approved mission, the Mars Observer scheduled for launch in 1992 and is actively planning for future missions. In the area of long-term habitation in low Earth orbit, the U.S.S.R., primarily through its Salyut and Mir space station programs and Earth-to-Orbit capacity, has logged more than 5,000 manned days in space compared to a U.S. total of approximately 2,000 man days, and the lead is increasing daily. However, the U.S. Space Station will provide our nation with an excellent permanent space facilities. In any case, U.S. leadership must be measured by our ability to achieve our national goals in space, not by some arbitrary criterion such as "days in orbit".

American space leadership has been and continues to be based on investment in advanced technologies in pursuit of challenging objectives such as the Viking landings on Mars and the development of the Space Shuttle. Thus, much of the leadership the U.S. maintained in the 1970s was based on technologies developed earlier

for the Apollo lunar landing program. The Civil Space Technology Initiative begun last year and the Pathfinder technology program proposed this year are designed to respond to the President's Space Policy call for continued U.S. leadership. There is no doubt that this investment is necessary if such leadership is to be maintained.

Question 55: In what other areas is our leadership in danger of being surpassed, and which countries are likely to do so?

To what do you attribute this situation?

Answer 55: The U.S. continues to lead the world in development and application of space technology. However, the area of expendable launch vehicle development and capacity is one in which our foreign competitors have become increasingly sophisticated with programs underway in Europe, Japan, China and the U.S.S.R. In areas of enabling technologies strong competition comes from Europe and Japan in fields such as microgravity processing and communication satellite technology. This situation is attributed to the growing maturity of foreign space capabilities and the high priority placed on space activity by relevant national governments and foreign industry which appreciate the high return on investment such activities generate.

Shuttle Manifest

Question 56: The target date for the first flight is August. At this point in time, is there any reason to think that you will not be able to meet this schedule?

What remain as the biggest threats to meeting this August launch date?

Answer 56: We are confident that, absent any unforeseen major problem, we will make the August launch date. Work is progressing steadily and many of the Shuttle's major elements are ready for assembly. Only testing on areas relating to the solid rocket motor remains to be done to confirm our assessment that we will meet the scheduled launch date.

Question 57: Since the August launch was originally scheduled for June, how has the delay to August affected the rest of the manifest - for instance, when is the second mission scheduled for launch?

Answer 57: Since the manifest planning associated with the June 1988 launch of STS-26 contained schedule margin in the four flights leading to the Magellan planetary mission (STS-30), it has been possible to maintain the Magellan launch window and the subsequent flight schedules. The launches prior to Magellan are now planned as follows:

STS-26	August 29, 1988
STS-27	October 27, 1988
STS-29	January 19, 1989
STS-28	March 2, 1989
STS-30	April 27, 1989

Question 58: The first planetary launch once NASA resumes Shuttle missions is the Magellan mission to Venus, scheduled for an April 1989 launch.

Is there any reason to doubt NASA's ability to meet this launch schedule, and under what circumstances would NASA have to delay this launch?

How will protecting the Magellan launch date likely affect NASA's Shuttle planning or the Shuttle manifest itself?

Answer 58: Protection of the planetary launch dates is a high priority in developing the manifest. The revision of the launch schedule with STS-29 before STS-28 contains four weeks of margin in the critical path to the Magellan launch (STS-30). In addition, the Magellan launch window remains open for four weeks beyond its scheduled launch of April 27, 1989. Contingency planning for program schedule slips beyond these margins requires a flight ahead of Magellan to be rescheduled after the Magellan launch.

Obviously, while contingency planning cannot protect against all unforeseen circumstances, we believe we are taking all the steps reasonably possible to protect the planetary missions.

Question 59: Are the two other upcoming planetary missions - Galileo to Jupiter and Ulysses to the Sun - on schedule for their respective launch windows, and are there any threats, either technical or budgetary, to meeting either launch window?

Answer 59: The Galileo and Ulysses missions are on schedule and are expected to meet their respective launch windows. There are no identified threats to our ability of the Shuttle to launch these missions.

STATEMENT OF DR. NORRIS J. KRONE, CHAIRMAN, ADVISORY COMMITTEE ON NATIONAL AERONAUTICS, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

THE STATUS OF NATIONAL AERONAUTICS

Mr. Chairman, on behalf of the American Institute of Aeronautics and Astronautics and the AIAA Advisory Committee on National Aeronautics that I chair, I would like to thank you for the opportunity to express our views on a few issues that we feel are critical to the nation. The AIAA is a non-profit, professional society of more than 40,000 engineers, scientists and students working in the aerospace field.

The principal objective of the Institute is to promote advancement in the aerospace sciences. We believe the advances in aeronautics are paramount to our continued leadership in the ever increasing competitive world markets of civil aircraft. Also, the superiority of our future military aircraft is a direct function of the relative level of our aeronautic expertise, and in this regard the NASA aeronautics technology program is critical to both civil and military aeronautics.

Last year our testimony to this committee emphasized the economic value of investment in the NASA aeronautics research and technology (R&T). We were gratified to see evidence that there is a growing appreciation of this. However, it is important to recognize that there is generally a 5 to 10 year lag between the investment and the payoff. In constant dollars, the NASA aeronautics programs were reduced by approximately 50% between 1980 and 1986 with only slight apparent effects on our current ability to build and market the best aircraft in the world. The health we have enjoyed is a direct result of the R&T investments made in the pre-1982 time period.

Our assessment of national aeronautics reveals a mix of good and bad news. First for good news:

- (1) Our total aerospace revenues are the highest in history at \$103 billion.
- (2) The trade surplus in 1987 of aerospace products has been reported to be \$13.7 billion--up from \$11.8 billion in 1986.
- (3) The aerospace industry employed 1.319 million workers in 1987.
- (4) Large transport sales projections in 1988 are good--380 commercial jetliners with a total value of \$13 billion compared to 355 aircraft delivered in 1987.

On the negative side of the ledger:

- (1) U.S. military aerospace products accounted for 60% of the shipments in 1987, and the high dollar value B-1 bomber and C-5B aircraft lines will be shut down in 1988 and 1989 respectively.
- (2) Exports of military aircraft account for \$2.5 billion of the trade surplus--principally the older F-16 and the F-18 aircraft--and these sales are likely to drop in future years.
- (3) The general aviation picture is bleak, with shipments down to 1,160 airplanes in 1987, the lowest ever recorded--down from 17,000 in 1979. In 1987, foreign-produced aircraft accounted for 50% of the deliveries of these aircraft with an associated trade deficit of \$811 million. The commuter aircraft field is dominated by foreign products and accounts for 35% of U.S. general aviation imports. Product liability is a principal factor in the decline of our general aviation industry, and legislation is needed to correct this problem.
- (4) The civil helicopter market is in a slump with units delivered down to 270 in 1987 from the 1980 peak of 1353 units and from 330 in 1986.

A close examination of the \$103 billion in aerospace sales reveals that 72% is accounted for by the aircraft industry, and it's in this area that the foreign competition is growing. Between 1985 and 1986, imports in the overall civil aircraft sector rose 28%, with commuter aircraft up nearly 60%, helicopter up 40%, and commercial aircraft up 24%. The substantial decline in the U.S. dollar against foreign currency is believed a factor in the leveling off of imports between 1986 and 1987 and the increase in our aerospace trade surplus.

The civil and military aircraft foreign sales markets will be challenged by consortia such as the proposed European Fighter Aircraft (EFA) group which joins firms from France, Germany, Italy, Spain, and the United Kingdom; Brazilian and Italian firms have joined to develop and produce the AMX fighter; and Agusta of Italy, MBB of Germany, Aerospatiale of France, and Fokker of the Netherlands have combined in the development of the NH-90 transport rotorcraft program. The airbus Industrie consortium has increased its penetration of the U.S. commercial transport market with sales of its A300, A310, A320, and A340 aircraft to four of our major domestic airlines. Exacerbating the situation is the direct support that many foreign governments supply to their aircraft industry.

We strongly believe that the key to maintaining our world leadership position in aeronautics in the near and long term is the strengthening of our research and technology programs. Our current technology lead--which

includes the fuel-efficient propfan subsonic aircraft (a direct result of a NASA program initiated several years ago) scheduled to enter service in the earlier nineties--will probably give us a three to five year advantage, but this advantage will erode if the present trend continues and our current level of aeronautic R&D support is not maintained and strengthened.

THE NASA AERONAUTICS PROGRAM

General Level

The FY 89 NASA budget allocated for aeronautics remains insufficient to conduct a program commensurate with the enormity of the stakes. This assessment is made with full recognition of the modest increases in the aeronautical programs since FY 87.

The NASA total aeronautics budget request is \$930.7 million (including \$117.4 million for the transatmospheric vehicle, commonly referred to as the NASP program). \$368.3 million of this amount, however, is programmed for R&PM (salaries, utilities, etc.) and \$63.8 million for essential and important facility improvements (wind tunnels, etc.), leaving \$414.2 million for the R&D activities. This represents a mere 3.6% of the total NASA request. With the NASP and the R&PM funds included, the aeronautical segment of the NASA budget is only 8.1% of the total NASA budget.

We believe NASA does a good job of managing the available resources and understands the areas of deficiency; however, they are faced with an enormous unsolvable problem under the current funding level. Simply stated, they have too many critically important technical and systems areas to cover and are spread alarmingly thin in most areas. As the technology becomes more and more sophisticated, the hardware and software become more complex, and the resources needed to make advances increase proportionately. This is true in all of the technology disciplines that make up the aeronautical "technology base." To further complicate this situation, NASA is supporting several large flight demonstration programs such as the X-29 and the advanced turboprop (ATP). We firmly advocate the necessity of these activities; however, they have likewise become more complex and expensive, which puts an even further strain on the aeronautics budget.

Technology Base Programs

We were pleased to see that the technology base programs have been increased by approximately \$63 million in FY 89. This is certainly a step in the right direction, but \$314.2 million is not adequate to cover the many potential advances possible in the diverse fields of aerodynamics and thermal

physics of flow fields, materials and structures, control and guidance, human factors of aviation, propulsion and power systems, and computational information sciences research. In terms of absolute dollars (not percentages), the propulsion and materials technology areas are ones that have been beefed up substantially in 1989. When one considers that the cost of developing one new aircraft (transport or fighter) is measured in billions of dollars, a good business decision would call for a substantial expansion of all of these enabling technology programs.

The Technology Validation Programs

One of the problems highlighted by recent studies (for example, the 1987 Defense Science Board's "Technology Base Management Study") is the lack of a mechanism for transitioning technology from the laboratory into operational use. We believe a key to accomplishing this in the aeronautics field is the use of technology demonstration and prototype vehicles. The Packard Blue Ribbon Commission on defense spending stated that prototypes have been used far too little. These programs act as a focus for research and technology efforts and produce the confidence for making the decisions necessary to include the technologies in operational vehicle designs. Also, these programs are needed to demonstrate the ability to integrate and show the compatibility of advanced technologies with existing subsystems and operating procedures--for example, an advanced propulsion system combined with an active wing surface boundary layer control system.

Another concern that we have is that the U.S. is not developing enough innovative concepts to feed the Nation's total long-term needs and to provide sufficient options for the development of new experimental or demonstration aircraft. To illustrate this point, I call the Committee's attention to NASA's proposed budget for "Technology for Next Generation Rotorcraft" and under "High-performance Aircraft Systems Technology." There are no funds proposed in FY89 for next generation rotorcraft. Under high-performance aircraft, only one of four projects from FY88 are continued, and no new ones are proposed.

It is recommended that the NASA R&D activities be focused on demonstration vehicles (or prototypes) in two principal areas: (1) high speed transports, and 2) commuter-type aircraft that include short take-off and rotorcraft vehicles.

High Speed Transports

We believe that high speed civil transport aircraft will be commercially viable within the next ten years. This conclusion is based on two major

factors. One, the projections of high growth of passenger miles on the North America-Europe, the North America-Asia, the Europe-Asia, and the other assorted long-range routes of the world. The projected passenger demand for these routes is expected to be over 300,000 passengers per day by the year 2000. Second, the large potential performance gains from advanced technology developments since the Concord was designed appear to make a Mach 2.5 to Mach 5 transport ticket price competitive with sub-sonic transport. The first country or countries to produce such a vehicle will be in position to capture a large percentage of the new aircraft sales, and the airlines that purchase aircraft will capture a large segment of the long-distance passenger transportation market.

The key to economic viability of a high speed transport is a near-term technology development and validation program that builds on the current technology base. The high temperature turbine, the lightweight materials and structures, the aerothermodynamics, and the flight systems technology programs must focus on providing and validating potential high speed transport performance predictions. Drag reductions and propulsion efficiency advantages of the order of 50% to 70% relative to the Concord are possible. Technology programs to reduce the environmental impact of noise (including the sonic boom) and the air quality must also be pursued with a high priority.

Rotorcraft and Commuter Aircraft

Another prime area where technology resources need increasing to meet the projected market opportunity is in the commuter class of aircraft. This commercial market includes an advanced high speed rotorcraft vehicle--for example, an advanced technology tiltrotor. The keys to capturing this market of the future are light, efficient propulsion systems that utilize high temperature components without the need for complex cooling systems, light-weight structures, and advanced flight control techniques.

As in the case of the high speed transport, the rotorcraft field represents an opportunity to focus near-term technology efforts in a way that will ensure our share of the future markets. The current funding of these technology areas in the current NASA 1989 program is not commensurate with potential economic gains of the future.

NASA AERONAUTICAL RESEARCH AND DEVELOPMENT FACILITIES

As we did last year, we recommend supplemental funding to support a major rehabilitation and upgrade of the NASA wind tunnel facilities. For many years, this important area has been underfunded. Many of these facilities are unique in the world and have traditionally been one of the major elements to

maintaining a superior aeronautical posture. There exists a need to refurbish existing facilities in order for them to maintain their efficient useability and a need to examine areas where technology has moved beyond the capability of the existing facilities. We are pleased to note that the Congress has recognized this problem and appropriated the first increment of funding to refurbish the 12 ft. pressure tunnel at Ames Research Center. We hasten to caution, however, that this is but the first step in a necessary but costly process for which NASA has developed a comprehensive five-year plan. In addition, there exist critical shortcomings in the Nation's ability to conduct systems research simulation in hypersonic aerodynamics, propulsion, and high temperature structures. The cost of upgrading the existing facilities and the creation of the essential new ones makes a national investment an absolute necessity.

Personnel

In a December 1987 Aeronautics Policy statement, the AIAA recommended, among other things, that "the NASA aeronautics budget should be doubled and the number of research personnel increased by 50% within three years." This recommendation resulted from workshop sessions in which a number of prominent industry, government, and academic representatives addressed the worldwide competitiveness of U.S. aeronautics technology today. We highly recommend that a civil service personnel increase of 15 percent be provided for NASA aeronautics research to accompany the 1989 budget increases.

CONCLUSION

We realize the serious deficit in the country's budget and the implications of the negative balance of trade. Also, we recognize the difficulties of raising the level of NASA aeronautics support under these conditions. The situation is not unlike that of a company that is operating in the red, with one of its divisions doing very well with the potential for doing better. It would be ill-advised and make the situation worse to starve the good division and inhibit its future ability to generate resources. The NASA aeronautics programs are key to the health of our aeronautics industry and, therefore, the security and economic well-being of the country. Strong government support for NASA aeronautics programs is an intelligent investment for America.